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Electronic Engineering

INCORPORATING ELECTRONICS, TELEVISION AND SHORT WAVE WORLD

PRINCIPAL CONTENTS

RADIOLYMPIA NUMBER

The Electron—The History of its Discovery
The Design of Small Single-Layer Coils—Data Sheet
Television Receivers at Radiolympia
"Televisor" Queries Answered

2/- NOV., 1947

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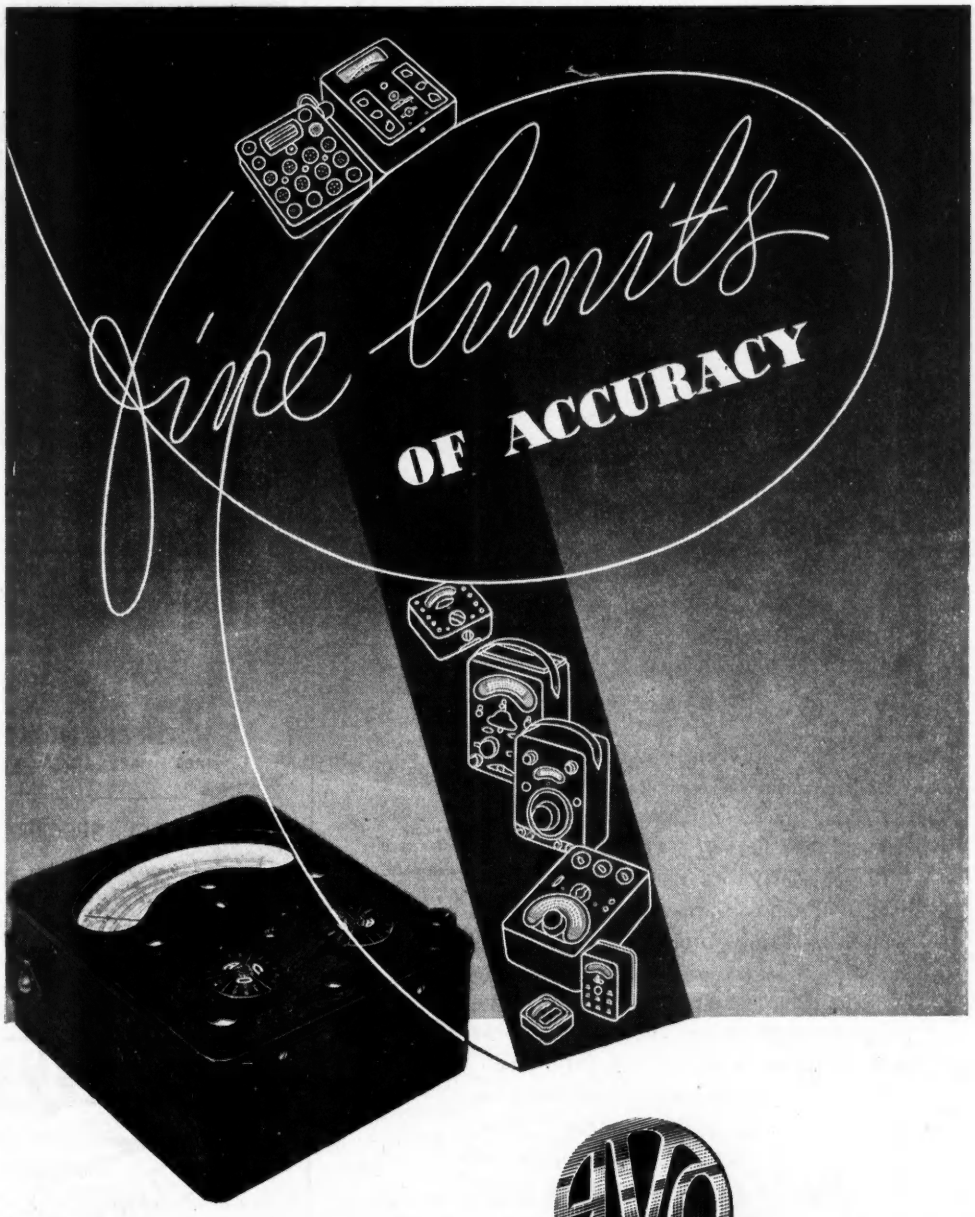

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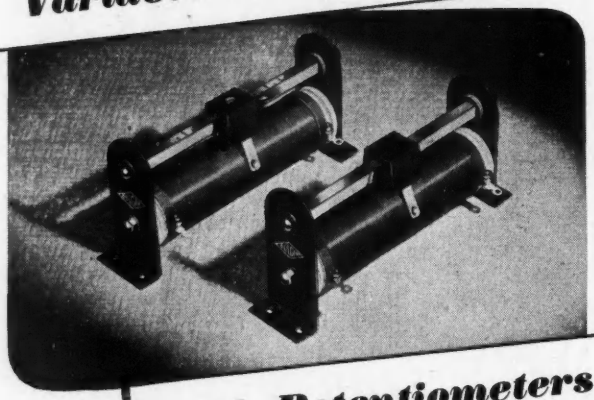

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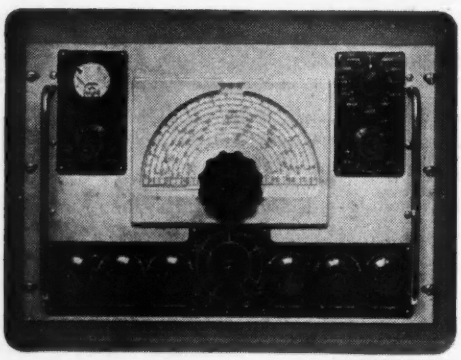

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We are not taking all this "sitting down." We have already done a lot of research, including the interrogation of German scientists, and of course, a very thorough survey of all that has been written in other countries. The problem of the "ground aerial" is quite different from that on air-borne aerials. We are quite hopeful of success. We would welcome co-operation from our readers. Will those of you who are troubled in this way help us by keeping us advised as to conditions when the nuisance is observed. If you will undertake to help, please write for a questionnaire. It doesn't matter whether or not you use a Belling-Lee aerial.

TO BE CONTINUED

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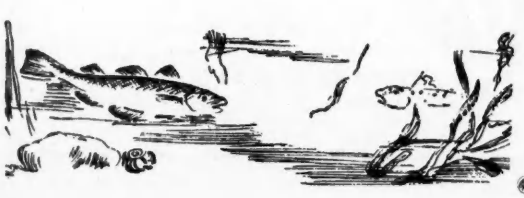

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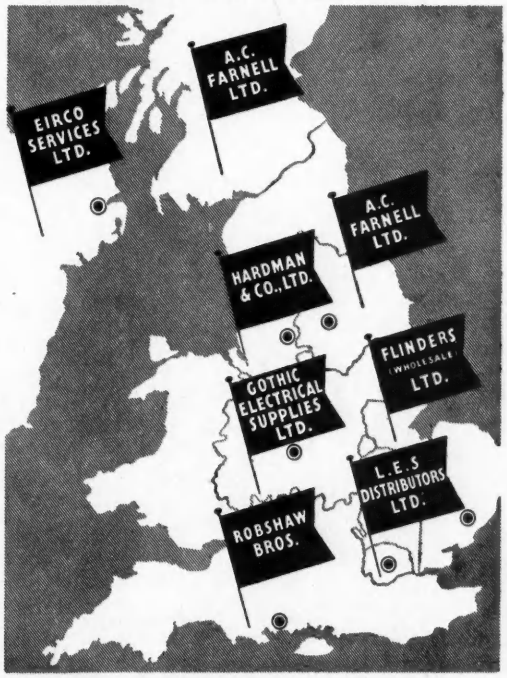

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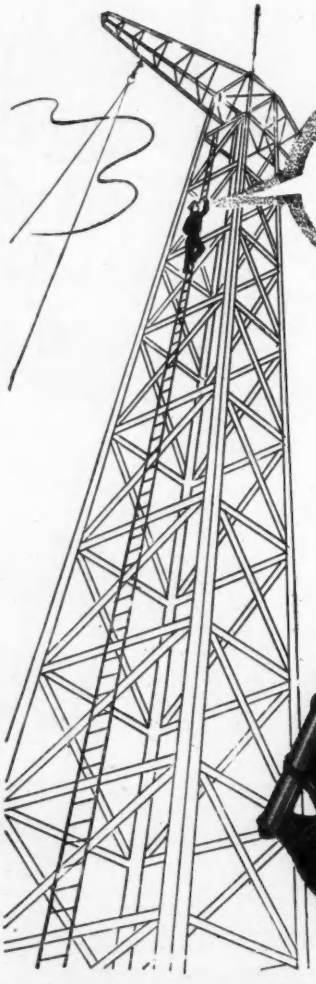

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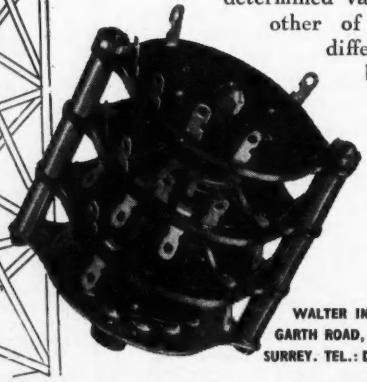

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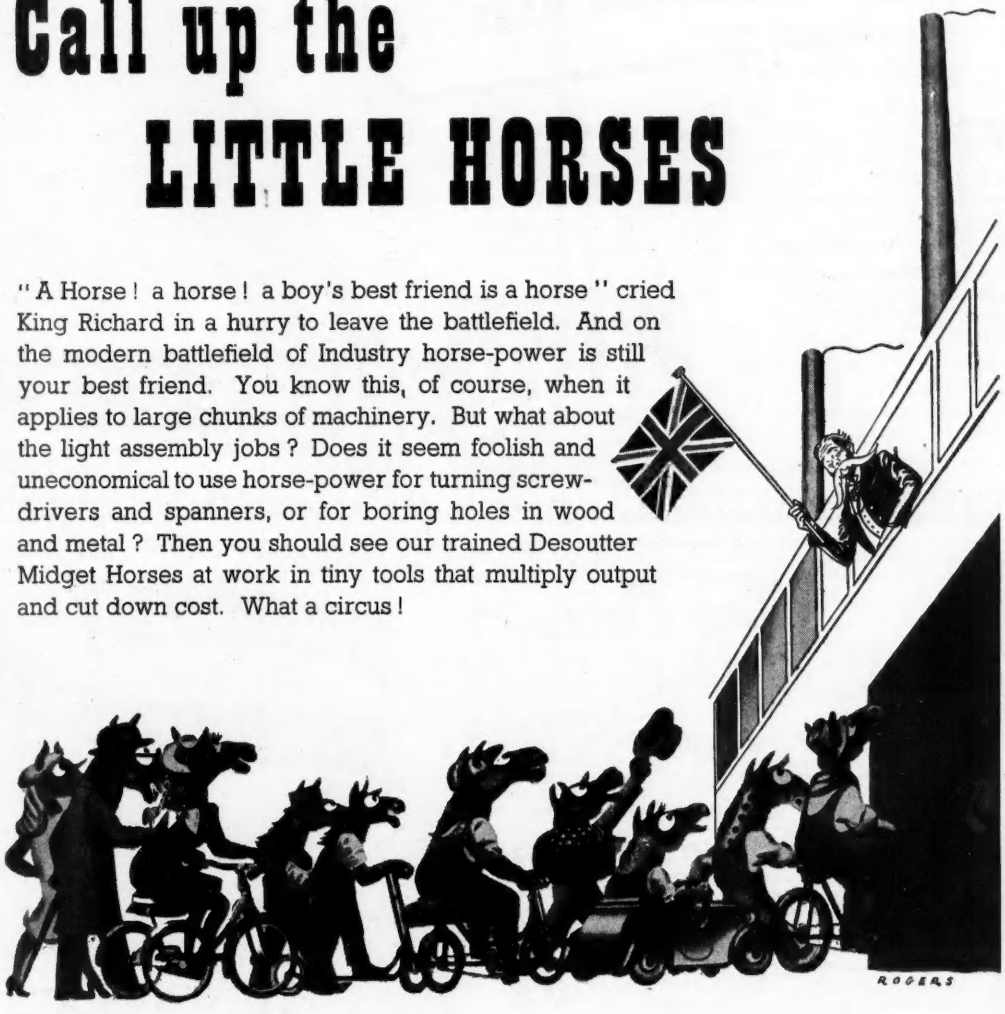

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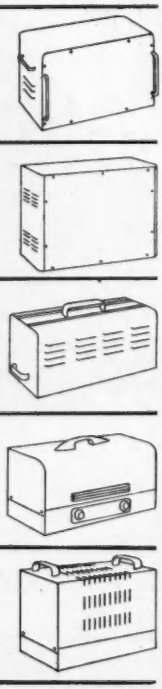

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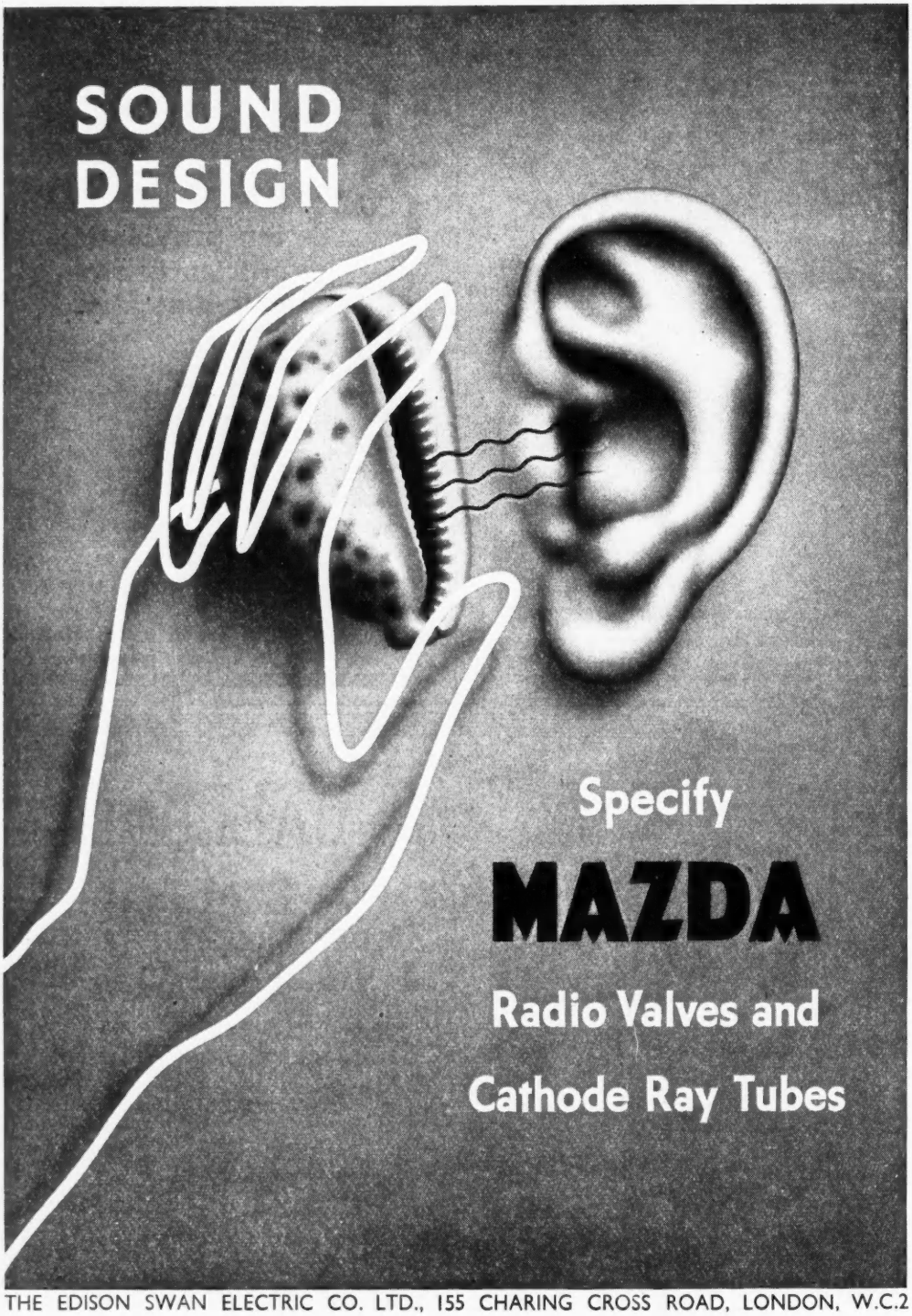

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Monthly (published last day of preceding month) 2/- net. Subscription Rate: Post Paid to any part of the World—12 months, 26/-. Registered for Transmission by Canadian Magazine Post.

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Comments

BOTH visitors and exhibitors seem to be agreed that Radiolympia was a success. The attendance figures reflect the intense interest which is taken in radio and, above all, television, and one of the causes for regret is that the quality of the demonstrations at times tended to discourage the would-be buyer.

It is an unfortunate fact that a temporary flaw in a picture will offset any amount of sales talk about brightness or quality, and while the technical man makes allowance for reproduction under exceedingly difficult conditions, the layman looks at the picture for ten seconds and decides that there isn't all that much in television to make him spend £80 on a set.

Still, the B.B.C. did an excellent job with the space and material at their disposal, and it is rumoured that they will be given more accommodation next time.

The standard of technical intelligence of the visitors was noticeably higher than before the war, no doubt because of war experience. Every other enquirer in the electronics section seemed to be an ex-radar operator, and in the main hall there was an absence of ordinary sightseers and more interest in what was in the cabinets than in the decorations.

In the electronics section, which was an innovation, the chief criticism was the lack of descriptive labels. Too much was taken for granted on the visitor's knowledge of the background of the apparatus shown, and it would have been helpful to have had more semi-technical diagrams. An outstanding example of an electronic exhibition was the Rediffusion radio heating exhibition at Dorland Hall some time ago, and several leaves could have been taken from their book in explaining the whys and wherefores of electronic applications.

A "technical expert," writing in one of the popular Sunday papers, stigmatised the exhibition as a technical flop, on the grounds that he did not see any of the improvements that might have been expected after the experience of war manufacture.

It is difficult to understand what revolutionary improvements from war practice could be applied to radio receiver manufacture direct. No doubt he was expecting to find walkie-seeies or television grass-cutters, or car P.P.Is. But if he had looked closely, he would have found many good solid improvements in detail, and what is equally important, a discarding of some of the frills which were introduced before the war for the sake of being different. No doubt the radio industry has taken careful note of his strictures, and will promise to be more enterprising in future.

P.S.—Isn't it surprising how little everyone has aged in ten years?

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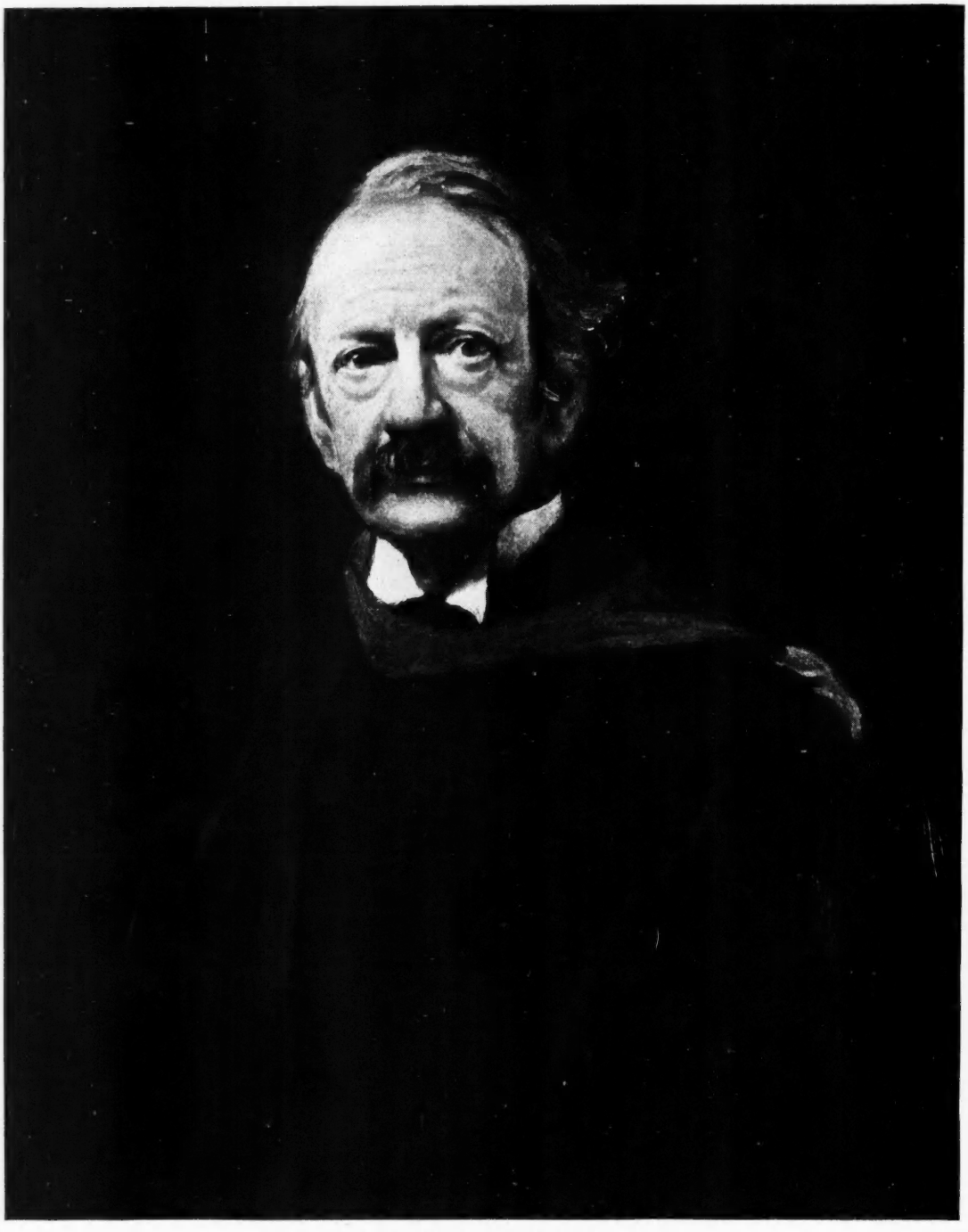

Sir Joseph Thomson, O.M., D.Sc., F.R.S.
1856 – 1940
Discoverer of the Electron

From the painting by de l'Hôpital, in the Royal Institution.

The Electron—*The History of its Discovery*

By J. A. CROWTHER, Sc.D., F.Inst.P.*

THE date is April 30, 1897; the place, the lecture theatre of the Royal Institution, Albemarle Street, London. The lecturer, Professor J. J. Thomson, Cavendish Professor of Physics in the University of Cambridge, is drawing near the end of a discourse on Cathode Rays. He has been expounding to his audience the difficulty — indeed, the impossibility—of fitting these somewhat obscure radiations into the general scheme of the orthodox physics of the times, and now he turns to give his own heretical, but inevitable solution.

"Let us trace the consequence," he says[1] "of supposing that the atoms of the elements are aggregations of very small particles, all similar to each other; we shall call such particles corpuscles, so that the atoms of ordinary elements are made up of corpuscles and holes, the holes being predominant. Let us suppose that some of the atoms get split up into these corpuscles and that these, moving with a high velocity, form the cathode rays." In spite of the fact that there is no mention of the word "electron" in the whole lecture, and that the hypothesis put forward is mainly a theory of the nature of matter than of electricity, it is from this announcement, and the evidence which Thomson brought in support of it, that Science, quite rightly dates the discovery of the Electron, the Jubilee of which we have just been celebrating. A fresh turn had been given to scientific thought; a new door flung open, through which Physics was to move to fifty years of unexampled discoveries.

Few great scientific discoveries emerge like Minerva from the brain of Jove, full-grown and fully armed; and the electron is not one of these few. On the theoretical side, the idea of a grain, or 'atom" of electricity is at least as old as Benjamin Franklin, and by 1871 Wilhelm Weber[2] had developed a whole theory of electromagnetism, on lines not very different from the theory which we now associate with the name of Lorentz, based on the assumption of the existence of positive and negative atoms of electricity, with equal and opposite charges, and small but definite mass. On the experimental side, the liberation of electrons in the free state was accomplished when Plücker[3] discovered the cathode rays in 1859; although their recognition was delayed for nearly forty years.

To us, looking back along the broad highway of physical science, it seems that the history of the electron should have begun with Faraday's researches on electrolytic conductance.[4] The fact that every ion in solution, whatever its nature, carries an identical charge, or at least some integral multiple of this charge, seems obviously to indicate that electricity is, so to speak, done up in bundles of this amount; and the early supporters of an "atomic" theory, did in fact, base their arguments on this fact. Faraday had, however, in 1840, thrown another, and apparently much larger pebble into the stream of scientific consciousness, the conception of electrical phenomena as a series of stresses and strains in a continuous incompressible medium. It was on this conception that Clerk Maxwell founded, in 1865, his Electromagnetic Theory of Light, synthesising, as it were, the three great sciences of dynamics, electricity and light. There are fashions in scientific theories as there are fashions in hats; and the well deserved prestige of the Faraday-Maxwell theory, particularly after its experimental verification by Heinrich Hertz in 1886, swept for the time being the tentative efforts at a corpuscular theory into the limbo of forgotten things; and threatened to sweep away the very idea of an electrical charge.

Nevertheless, occasional voices were raised in its defence. Helmholtz, in a Faraday Lecture at the Royal Institution is reported to have said[5] "The most startling result of Faraday's law is this: if we accept the hypothesis that elementary substances are composed of atoms, we cannot avoid concluding that electricity also is divided into definite elementary portions which behave like atoms of electricity." In a paper read before the British Association in 1874, but not published until seven years later, the ingenious Dr. Johnstone Stoney[6] of Dublin, drew attention to the uniqueness of this ionic charge, and gave the first estimate of the magnitude of what we know now as the electronic charge.

In a later paper,[7] "On the doublets of the Alkalis," Johnstone Stoney goes the length of giving a name to this unique charge, and proposes that it shall be called an "*Electron.*" As this is the first appearance of the now familiar name in print, and as the paper is not very generally accessible, readers may be interested to see a quotation.

"Attention must be given" writes the author "to Faraday's Law of Electrolysis, which is equivalent to the statement that in electrolysis a definite quantity of electricity, the same in all cases, passes for each chemical bond that is ruptured. It is shown that the amount of this very remarkable quantity of electricity is about 10^{-20} of the usual electromagnetic unit of electricity. This is the same as 3×10^{-11} of the much smaller C.G.S. electrostatic unit. A charge of this amount is associated in the chemical atom with each bond . . . These charges, which it will be convenient to call "*electrons,*" cannot be removed from the atom, but they become disguised when atoms chemically unite. If an electron be lodged at the point P of the molecule which undergoes the motion described in the last chapter, the revolution of this charge will cause an electromagnetic undulation in the surrounding ether."

The electron was therefore, originally, just a natural unit of charge. Its reinstatement as an entity was due, strangely enough, to a re-examination of the Faraday-Maxwell theory, by Joseph Larmor,[8] who found that only by assuming a "monad" or atomic structure for electricity was it possible to explain the phenomenon of permanent magnetism. To these monads, which he viewed as "freely mobile intrinsic strains in the ether, supernaturally created" he transferred, at the suggestion of still another great Irishman, Fitzgerald, Johnstone Stoney's term, electron. The electron was thus conceived, as a mathematical necessity. Meanwhile it still remained to be born.

It had long been the general opinion that further progress in electrical knowledge might be expected to come from a study of the electric discharge in gases at low pressure; in which electricity, freed more or less from the shackles of ponderable matter, might

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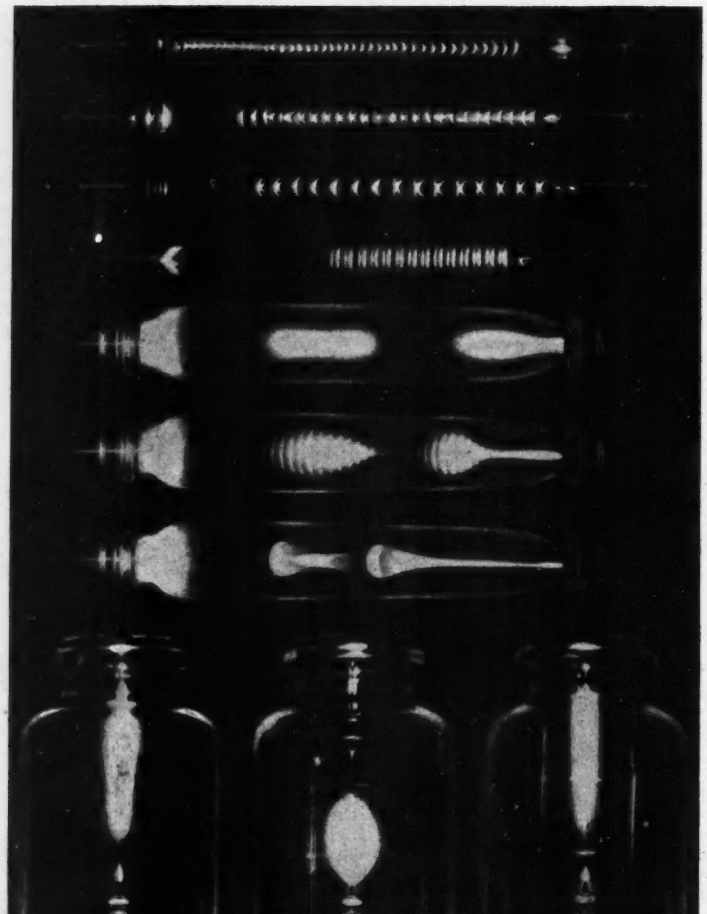

Fig. 1.—**Early forms of tubes showing the striations and glows associated with the discharge of electricity through gases. (Geissler tubes). The gas pressure is too high to allow the cathode rays to be seen. The beginnings of the Crookes dark space is just visible on the left in the third figure from the top.** —*Warren de la Rue, 1880.*

be expected to reveal something of its own nature. But it was also the opinion that such experiments would be "premature," and ardent young researchers were solemnly warned by their professors to avoid this line of country, as being more likely to lead to a loss of reputation than an increase in knowledge. Under such circumstances progress was slow, and although the cathode rays were discovered by Plucker[9] (1858) and their deflection by a magnet observed (Fig. 2), thirty years were to elapse before any sustained and well direced attack was made on the problem. There were, it is true, many desultory observations, the general effect of which was to darken rather than illuminate the subject.

The main outlines of the "cathode ray controversy" are well known. British physicists, following Varley,[10] conceived the rays as a stream of atoms or molecules which, becoming charged by contact with the negative cathode acquired a negative charge and were repelled from it. Continental physicists, in general, with, as we have seen, the notable exception of Helmholtz, supported a wave theory of the phenomenon. The latter relied on the absence of any indication that the rays could be deflected by an electric field, as charged particles would be; the British school rested their argument on the incontrovertible fact that no known or conceivable type of wave-motion could be deflected in a magnetic field.

The first real attack on the problem was made by Schuster[11] who measured the deflection of cathode rays in a known magnetic field (Fig. 3). Assuming the rays to consist of charged particles, the radius r of their path in a magnetic field H is given by mv/He, where m, v and e are the mass, velocity and charge of the particle, and are, of course, all unknown. The maximum velocity which a particle could acquire in the potential drop V between anode and cathode would be given by $Ve = \frac{1}{2}mv^2$ which would enable us to calculate v and e/m, if the voltage across the tube was measured. On this supposition, Schuster's results would have given a value for e/m of 3.5×10^6. The value for a hydrogen ion in solution (the Faraday constant) is approximately 10^4, so that on the probable, though of course unproved, assumption that the charge is the same in both cases, the mass of the cathode ray particle would be about 1/350th of that of the hydrogen atom. Schuster, however, thought at the time that the energy given to the particle by the electric field would be all expended in driving it against the viscous resistance of the residual gas in the discharge tube, and that the velocity v in the magnetic field would be merely the appropriate velocity of thermal agitation of a molecule at the temperature of the tube. With this interpretation the value of e/m was about 2,000, a value which would be quite appropriate for, say, a triatomic ion of nitrogen. Commenting on the experiments later, Schuster said: "The separate existence of a detached atom of electricity never occurred to me as possible, and had I openly expressed such heterodox opinions, I should hardly have been considered a serious physicist."

For the sake of completeness of this record it may be mentioned that Schuster's experiment was repeated by Wiechert[12] a few months previous to Thomson's Royal Institution lecture. Wiechert made the assumption that the velocity of the cathode particles (if particles they were) must lie between the maximum they could acquire in falling through the full potential difference across the tube, and a minimum value equal to that produced by a fall through the cathode fall of potenial (*i.e.*, the poten-

tial difference between the metal cathode and a point in the gas on the boundary of the cathode dark space). With these assumptions the value of e/m would lie between 4×10^7 and 4×10^6, indicating that the particles are, in either case, much lighter than the hydrogen atom. The assumption that a particle in a discharge tube cannot have a velocity less than that due to a fall through the cathode dark space (about 200 volts) is entirely without foundation. The fact that Wiechert was content to leave his communication in the comparative obscurity of a local journal, may, perhaps indicate some doubt about the matter on his own part.

In the meantime two further, apparently conflicting, pieces of evidence had been added to the confusion. Lenard[13] had shown that the cathode rays were able to penetrate thin sheets of aluminium or gold. The penetrating power of the rays, which was roughly inversely proportional to the density of the absorber, was far too high to be consistent with any particle theory of the radiation, if the atoms were to be regarded, as they always had been, as little solid spheres. On the other hand, Perrin[14] had shown that the cathode rays carried a negative charge, by collecting them in a small shielded metal cylinder connected to an electrometer, and Thomson[15] had clinched the argument by showing that if the cathode rays were deflected in a magnetic field, this charge accompanied them, which was clearly inconsistent with any wave theory. (Figs. 4 and 5.)

What the situation required was something more than an unambiguous method of determining the size of the cathode particles (on the still unproved assumption that they *were* particles); it demanded a fresh viewpoint, embracing in its scope all the discordant mass of facts which had by now accumulated. What was needed was not merely a theory of the cathode rays, but a new theory of matter. It was precisely because it provided this that J. J. Thomson's pronouncement, with which this brief summary opens, has rightly been regarded as of the highest historic importance.

Nevertheless, it may be stated, for the sake of any still interested in formal priorities, that this lecture, given on April 30, 1897, and reported in the *Electrician* of May 21, 1897, does give the first *unexceptionable* estimate of the value of e/m for the cathode particles. The result was arrived at by combining a measurement of the magnetic deflection of the

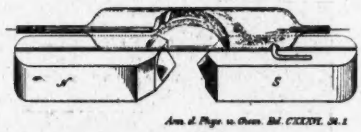

Fig. 2.—Diagram showing the deflection of the luminous discharge in a magnetic field.

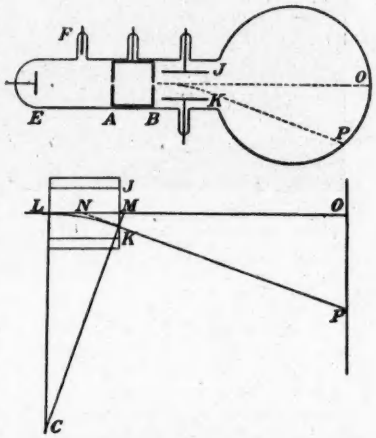

Fig. 8.—Diagram illustrating the construction and mode of action of Thomson's e/m tube.

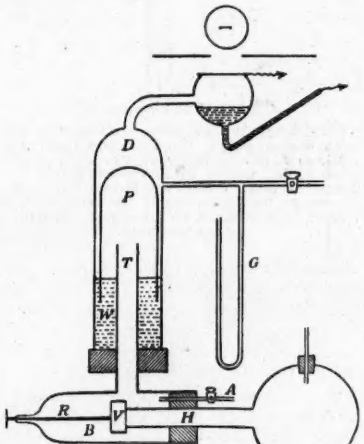

Fig. 9.—Diagram illustrating Thomson's method of determining the charge on a gaseous ion. The gas above the water in the upper chamber is ionised by a beam of X rays. The gas is supersaturated by adiabatic cooling produced by the sudden fall of the piston P. A cloud forms on the ions. The mass of a drop is deduced from the rate of settling of the cloud, and the charge brought down is measured by connecting the water surface to an electrometer. The same method was used to determine the charge on an electron the electrons being liberated by illuminating the metal plate, closing the vessel, with ultra-violet light.

particles with an estimate of their kinetic energy obtained by converting this energy into heat by absorbing the rays in a thermocouple. The method was obviously not capable of great accuracy, and the result obtained (6.3×10^6) was, in fact, only about one-third the true value; but at least it was not open to any theoretical objections.

A few weeks later a fresh determination of e/m was published by Kaufmann[16] in a paper received May 21 and published June 15. Kaufmann followed Schuster's method, but assumed that the velocity of the rays was that produced by a free fall through the full potential difference across the discharge tube; an assumption which he attempted to justify experimentally by showing that the value obtained was uninfluenced by small changes in pressure of the gas in the discharge tube. It was a fair assumption that, if the particles were actually being slowed down by collisions with the residual gas in the tube, the effect would be increasingly apparent as the pressure increased. Kaufmann's value, 1.77×10^7, is within one per cent. of the most recent determinations of this constant; a very remarkable achievement. Kaufmann, however, regarded the hypothesis that the particles were torn from the atoms as an illegitimate interpretation of his results.

In the meantime, Thomson[17] had removed the last objection to his theory by demonstrating the electrostatic deflection of the cathode rays. Previous failures had, as he suggested in his earlier lecture, been due to the electrostatic screening effect of the residual gas in the discharge tube. Kaufmann and Aschkinass[18] confirmed this result. The way was now clear for what is undoubtedly the best known of all Thomson's experiments, the determination of e/m by the electromagnetic balance or "e/m tube"; replicas of which are to be found in most national Science Museums. (Fig. 6.)

If a particle of charge e is projected with a velocity v at right angles to an electric field X and a co-terminous magnetic field H, the former exerts on the particle a force Xe, the latter a force Hev. If the fields are adjusted until the particle is undeflected, its velocity v is obviously given by the ratio X/H. A measurement of either the magnetic or the electric deflection will then permit the value of e/m to be calculated without ambiguity. In this way Thomson[19] obtained the mean

value 7.7×10^7, in a variety of gases, and with various electrodes. (Figs. 7 and 8.)

It is characteristic of the fertility of Thomson's genius, that even in this early paper (which, one would imagine, already contained more than enough exciting material to satisfy most authors) Thomson is already discussing how his new "corpuscles" would arrange themselves within the new atom. It is here that the rings of electrons with which we are now all familiar, make their first appearance in print.

Thomson, as we have already noted, speaks of the new particles as "corpuscles," not electrons. There was, in fact, no evidence so far available that the charge on the corpuscle was, indeed, the electronic charge, as defined by Stoney: much less that the corpuscle was the disembodied electric charge defined by Lamor. The belief in the smallness of the corpuscle rested largely on its power of penetrating matter, and Thomson, at least in his earlier papers, inclined to the belief that the charge on the corpuscle might be considerably greater than that on an electrolytic ion.

An experimental determination of the latter had recently been made by J. S. Townsend[20] (Phil. Mag. 45, p. 125, 1898) in a paper which, in the excitement of the times, has attracted perhaps less attention than it deserved. In the electrolysis, say, of water, not all the ions surrender their charge to the electrodes: a few escape with their charges intact into the air, where each, owing to the effect of its charge becomes the nucleus of a small drop of water. Townsend determined the total charge Ne and total mass Nm of the cloud thus formed by absorbing it in sulphuric acid in an insulated vessel connected to an electrometer. The average mass of the individual drops he determined by watching the slow rate of fall of the cloud under gravity, and applying Stokes's equation for the rate of fall of small spheres in a viscous medium. It was then a simple matter to deduce the total number of drops N, and hence the charge e on each. Townsend's final value, 5×10^{-10} e.s.u., for this fundamental constant—Johnstone Stoney's electron—was within 5 per cent. of the now accepted value. Still more important perhaps was that, in his ingenious use of Stokes's equation, he had provided a model which was followed by nearly all later experimenters in the field, until the introduction of X-ray analysis.

The method was applied, in modified form, by Thomson[21] to find the charge on the ions in gases ionised by Röntgen rays. (Fig. 9.) The result, 6.5×10^{-10} e.s.u., was sufficiently close to Townsend's value for the charge on ions in solution to allow the inference to be drawn that the charges were identical, and to raise some expectation that this might also apply to the "negative corpuscle." Some decision on this question was obviously becoming urgent, and Thomson[22] continued the attack.

To use the cathode rays themselves as nuclei for the condensation of a cloud of water drops was, probably, beyond the experimental resources of the times. Fortunately cathode rays were not the only available sources of "corpuscles." Negative corpuscles were also emitted by a zinc plate illuminated with ultraviolet light, or by any incandescent metal. The values of e/m for these particles, (7.3×10^6 for the former and 8.7×10^6 for the latter), established their identity with the original corpuscles of the cathode rays. By illuminating a zinc plate in a space supersaturated with water vapour each corpuscle could be made to form the nucleus of a tiny water drop, the charge on which could be determined by a modification of the method used by Townsend. The result, 6.8×10^{-10} e.s.u., was within the rather wide limits of experimental error allowable at the time, identical both with the charge on a gaseous and on an electrolytic ion. This identity of charge enabled Thomson to say with certainty that the mass of the corpuscle is a small fraction (about one-thousandth, on the data then available) of that of the hydrogen atom.

The results thus briefly described, were communicated by Thomson to a meeting of the British Association at Dover, 1899. The communication was made the occasion for a general attack on Thomson's views led by H. E. Armstrong, and it may be emphasised that the work described in the previous pages had met with very little acceptance, outside the small and enthusiastic band of workers in the Cavendish Laboratory. Records of the discussion at the meeting are painfully discreet,[23] nevertheless it was from this meeting that the "corpuscle" began to be accepted as a legitimate member of the scientific community.

One further question remained to be answered: Writing the following year Oliver Lodge[24] says "J. J. Thomson adduces experimental facts in favour

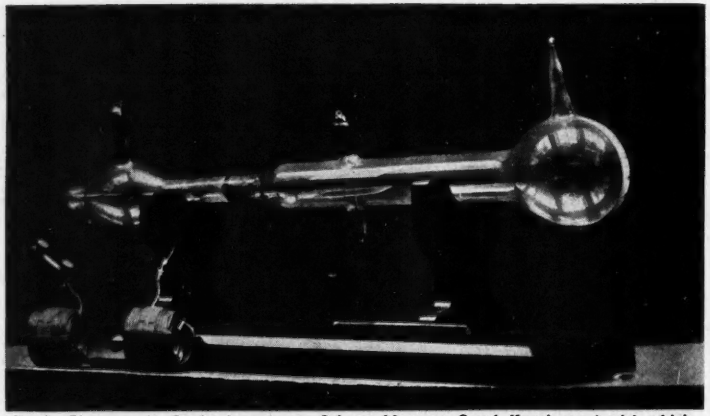

Fig. 6.—**Photograph of tube (now in the Science Museum, South Kensington) with which Thomson demonstrated the electrostatic deflection of the cathode rays. The deflecting plates are seen in the middle of the tube. Twin coils for applying a magnetic field stand beside the tube.** —*Crown Copyright*

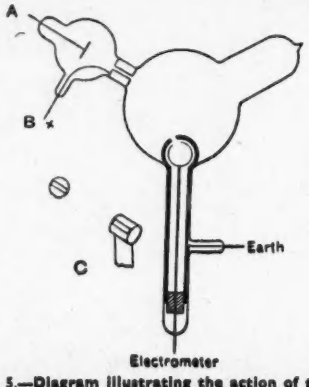

Fig. 5.—**Diagram illustrating the action of the tube shown in *Fig.* 4. The rays from the cathode A fall normally on the walls of the glass bulb. Under these circumstances the Faraday cylinder C shows no charge, but begins to charge up negatively if the rays are deflected by a magnet to fall on the aperture of the chamber.**

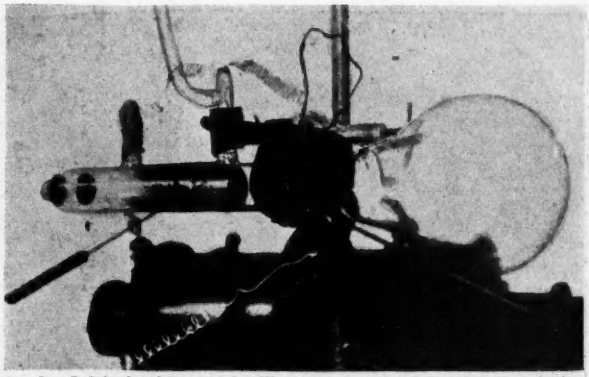

Fig. 7.—**Original tube, used by Thomson, for the determination of e/m for cathode particles ; preserved in the Cavendish Laboratory, Cambridge. The magnetising coils are shown in position. The induction coil for running the discharge is shown in the background.**

Fig. 3. (left)—**Photograph showing the path of the cathode rays being bent into circular arc by a magnetic field acting at right angles to the plane of the paper. The rays are emitted by the horizontal hot filament at the left of the tube and describe rather more than a semicircle before being absorbed by the residual gas.**

of the real and even isolated existence of charged corpuscles, whether they be electrons or not." The term "electron" had already been commandeered, as we have seen, by Larmor to denote an isolated unit of pure electricity. Was the "corpuscle" indeed this unit, or was it a particle of some fundamental kind of matter, a "fourth state" as Crookes had called it, carrying an electronic charge?

Thomson[25] himself had shown that an isolated electric charge would exhibit inertia owing to the energy associated with its electromagnetic field. The electromagnetic mass, however, would increase fairly rapidly as the velocity of light was approached, whereas, in those pre-Einstein days it was assumed that ordinary "mechanical" mass would be constant. The variation for the speeds reached in a cathode-ray tube in those days was negligible, but radium ejected corpuscles with velocities up to within a few per cent. of that of light. Measurements of e/m for these particles carried out by Kaufmann[26] (*ibid.* 4, p. 54, 1902; Ann. De Phys. 19, p. 487, 1906) between 1901 and 1906, showed that the mass of the corpuscles did, in fact, increase markedly as the velocity of light was approached, and in his final paper he was able to announce that if there was any part of the mass which was ordinary mechanical mass it was very small in comparison with the part which was of electrical origin. In other words, the corpuscle was, indeed, a free electron.

Many physicists had drawn the same conclusion, perhaps a little hastily, even from Kaufmann's earlier measurements, and by 1904 the particles were beginning to be spoken of as "electrons" except in the Cavendish Laboratory, where Thomson, though one of the first to make the identification, still clung, either from force of habit or from affection, to his old term "corpuscle." It was only after the hiatus produced in fundamental research by the 1914-1918 war, that he accepted the new name conferred by others on the infant which his genius had brought to birth twenty-one years before.

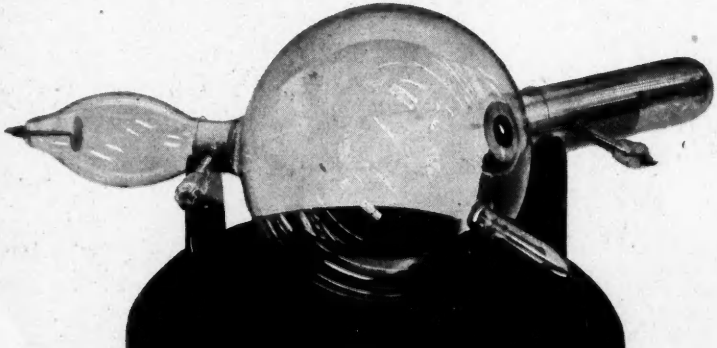

Fig. 4.—**Photograph of tube used for demonstrating the fact that the cathode rays are accompanied by a negative charge.**

Crown Copyright. From an exhibit in The Science Museum, South Kensington.

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Television at Radiolympia

A record of the television receivers shown at the Radio Exhibition, arranged in alphabetical order of manufacturers.

Picture sizes given are nominal, and relate to 9-in., 12-in. or 15-in. tubes.

All receivers use magnetic focusing and deflection.

Alba Television-radiogram with auto record changer.

Philco Console, type A.1708, with double doors to conceal tube and controls when television is not used.

R.G.D. de luxe television receiver, Model 2547, TR., with controls at side of cabinet.

Alba

Television-radiogram, incorporating 5-valve all-wave superhet with band-spread tuning. Picture size 8 in. by 6 in. Garrard automatic record changer.

Type T.421 employs a 12 in. tube.

Baird

The " Lyric " console. Combined television and 2-band radio receiver. Picture size 10 in. by 8 in. Oak cabinet in various tones

Price :

£221 11s. 4d. including P.T.

Features :

Pull-down shutter over television screen.

The " Garrick " console. Combined television and 2-band radio receiver. Picture size 10 in. by 8 in.

Price :

£199 15s. 6d. including P.T.

Features :

Push-button wave-band selection and vision.

The " Grosvenor " large screen receiver. Incorporating 11-band radio receiver and auto-changer gramophone with recording unit and playback arrangement. Picture size 22 in. by 19 in., direct screen viewing.

Features :

Large bulb C.R. tube with coated metal screen. Suitable for public viewing.

Beethoven

Type T.918 console, with a picture size 8 in. by 6 in. Television only.

Price :

£95 including P.T.

Bush

Type TV.2 for television only has a picture size 10 in. by 8 in.

Console Model Type T.91. Picture size 8 in. by 6 in. Two front panel controls.

Price :

£72 0s. 3d., including P.T.

Cossor

Model 901 is an all-wave console giving a picture size 12 in. by 10 in.

Console Model 902 in walnut cabinet. Picture size 8 in. by 6 in.

Price :

£96 8s. 9d. including P.T.

Features :

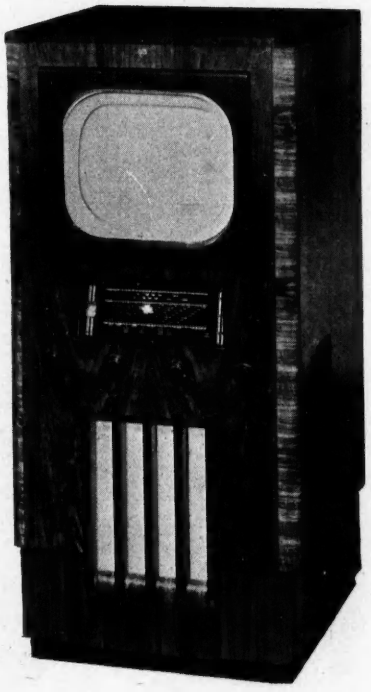
Ion trap in C.R. tube. Automatic linearity control in timebase circuit. Cathode follower video output.

Dynatron

A new " Ether Sovereign " de luxe television auto-radiogram giving a 10 in. by 8 in. picture. Cabinet also provides storage space for records.

Above: **Kolster-Brandes Console Model CV.40, with miniature valves and tone control.**

Below : **Mullard MTS.315 All-wave Receiver and Television, in walnut cabinet.**



Radio section similar to the " Ether Conqueror."

Price :

£394 3s. 3d. including P.T.

Ekco

Type TSC 30A is a console model giving an 8 in. by 6 in. picture.

Price :

£85 1s. 4d. including P.T.

Model TSC48 console model. Picture size 10 in. by 8 in., mirror viewing. Radio receiver giving selection of 4 medium and 1 long-wave stations and television. Controls at side of cabinet.

Features :

Miniature valves (Mazda). Sound-on-vision filter. Special arangement for common aerial for radio and T/V. Variable selectivity control. Pre-set radio tuning.

Model TS.46. Table cabinet in dark walnut with bleached walnut and aluminium front. Picture size 8 in. by 6 in.

Price :

£74 including P.T.

E.R.I.C.

A sound and vision console with 10 in. by 8 in. picture, type TR.1840. (The Electrical & Radiological Inst. Co.).

Ferguson

Type 841.T gives an 8 in. by 6 in. picture, and is a console for television only.

Ferranti

Model 1246. On tubular stand. Copper lacquer and cream finish cabinet. Sound and vision only. Picture size 10 in. by 8 in.

Price :

£109 12s. including P.T.

Model 1146. Table model in walnut and ebonised cabinet. Picture size 8 in. by 6 in.

Price :

£87 11s. 2d. including P.T.

Features :

Both models have 2-knob control-on-off volume and brightness. Aerial input adjustment. Noise suppression.

G.E.C.

Table Model Type BT.7092. Television and 3-wave-band radio; 6-valve superhet. Picture size 8 in. by 6 in.

Price :

£105 13s. 9d. including P.T.

Features :

Flat-ended tube. Interference

elimination. Brightness, focus and volume controls. Sockets for pick-up.

BT.7094 is a console of similar performance.

Price:

£118 11s. 6d. including P.T.

Haynes

T.R.F. television receiver console Type HR.77. Picture size 12 in. by 10 in.

Price:

£146 13s. 4d. including P.T.

H.M.V.

Model 1803. Console vision and sound receiver. Picture size 12½ in. by 10 in. Adjustable noise suppression. Elliptical loudspeaker.

Price.:

£126 6s. 3d. including P.T.

Model 1852. Projection television receiver. Picture size 20 in. by 16 in. using 4-in. projection tube. Schmidt projection system. Combined T/V and all-wave push-button radio. H.T. 25 KV.

Price:

£438 4s. 5d. including P.T.

Features:

Automatic tube protection in event of timebase failure. Provision for supplying radio programme on extension speaker during T/V reception.

Model 1901. All-wave television-radiogram. Picture size 10 in. by 8 in.

Model 1804. Console with television only. Picture size 12 in. by 10 in.

Price:

£76 0s. 11d. including P.T.

Invicta

Type TL.21 television console. Picture size 8 in. by 6 in.

Price:

£76 10s. 3d. including P.T.

Kolster-Brandes

Console Model CV.40. Sound and vision only. Picture size 10 in. by 8 in.

Price:

£94 18s. 2d. including P.T.

Features:

Miniature valves (Brimar). Tube H.T. from timebase. Sound tone control. Temperature compensation on oscillator.

McMichael

All-wave console type with 10 in. by 8 in. picture.

Table model with 8 in. by 6 in. picture.

Marconiphone

Type VT.50.A A table model for sound and vision only. Picture size 8 in. by 6 in.

Price:

£76 0s. 11d. including P.T.

Masteradio

Console Type T.48 for sound and vision only. with 10 in. by 8 in. picture.

McCarthy

Felgate Radio, Ltd. Two models: MCC.1 and MCT.1, both giving 8 in. by 6 in. pictures. MCC.1 is a console.

Mullard

Console model Type MTS.315. Walnut cabinet. Picture size 10 in. by 8 in. 7-valve all-wave receiver. Interference suppression.

Murphy

Type V.114 table model in rosewood and mahogany cabinet. Picture size 8 in. by 6 in.

Price:

£66 12s. including P.T.

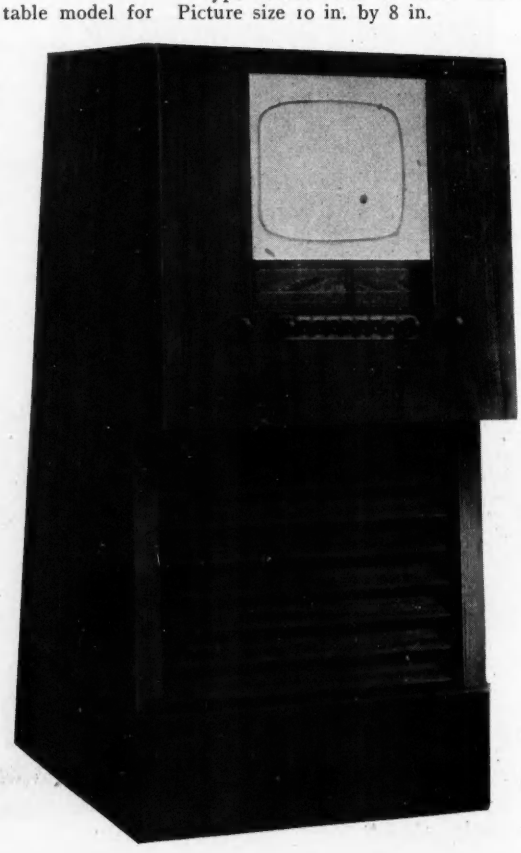
Features:

Miniature valves (Mazda). Automatic noise suppression.

Type V.116 console with doors. Picture size 10 in. by 8 in.

(Left) Murphy Console Type V116. Picture size 10 in. by 8 in.

(Right) G.E.C. Type VT7094 with push-button tuning for radio.



Price:
£98 13s. 4d. including P.T.
Features:
Acoustic tube behind speaker. High note diffuser.

Philco

Console Model A.1708 with doors. Picture size 8 in. by 6 in. 10 in. speaker.
Price:
£90 0s. 2d. including P.T.
Features:
Variable top-cut tone control.

Philips

Console Model 663.A. Radio 3-band receiver and television. Mahogany cabinet. Picture size 10 in. by 8 in.

Pilot

Console Type V89, sound and vision only. Picture size 8 in. by 6 in.

Pye

Console Type D.16.T. Picture size 8 in. by 6 in.
Price:
£64 5s. 10d. including P.T.
Table Model Type B.16.T. Picture size 8 in. by 6 in.
Price:
£51 8s. 8d. including P.T.
Features:
Two controls on front: On-off brightness and volume. Interference suppression on sound and vision.
Price:
£51 8s. 8d. including P.T.

R.G.D.

Console Model 2347 T.R. Walnut and ebonised cabinet with controls at side. Picture size 10 in. by 8 in.

R.I.

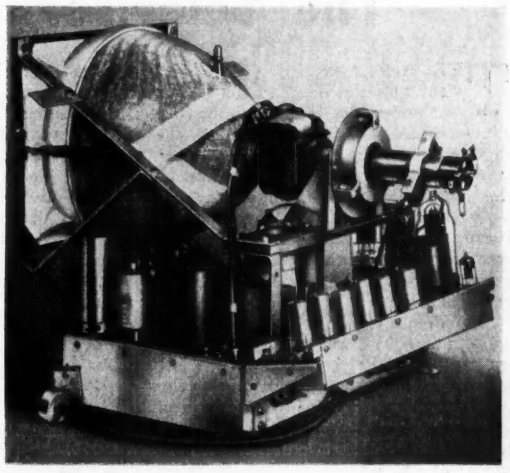
Console Type T484 with 10 in. by 8 in. picture, sound and vision only. (Radio Instruments, Ltd.).
Price:
£136 9s. 5d. including P.T.

Sobell

Model T.107 all-wave console with picture size 10 in. by 8 in.
Feature:
Sliding panel covering the tube when radio is being received.
Price:
£170 19s. including P.T.
The model T.87 is a table receiver for sound and vision only, with an 8 in. by 6 in. picture.

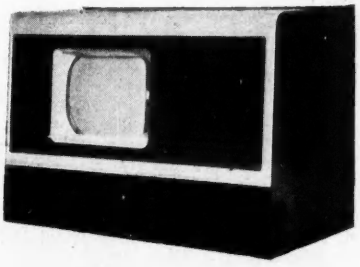
Ultra

Two models for television only. The W.470 is a console with a 10 in. by 8 in. picture, and the V.470 a table model.
Features:
Focus Drift Compensation A.F.C. and variable sensitivity.



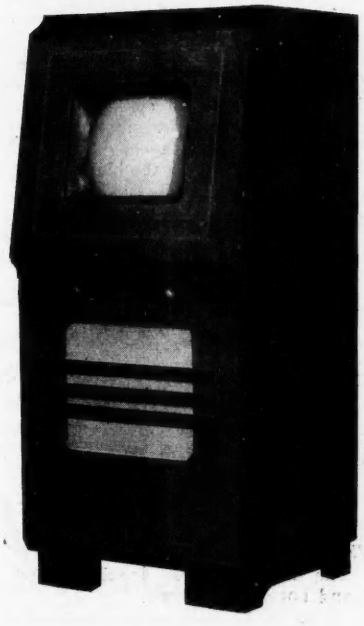
View of chassis of Cossor television receiver Model 902.

Below:
Ferranti Table Model 1146, with vibrationless chassis mounting and two-knob control.



Below (right) **Pye Model D.16.T console with 9 in. tube.**

(left) **Bush T.91 console receiver with two-knob control at front and pre-set controls at side of cabinet.**



The Televisor — *Notes and Queries*

THE interest shown in the Televisor and the demand for copies of the booklet left no doubt that a need was being fulfilled in publishing constructional details in a convenient form, and thanks are due to the many readers who made favourable comments on the design and performance. The general opinion was that the circuits and mechanical layout were well-chosen for the home constructor.

The demonstrations, which at first were marred by excessive diathermy interference (in common with all other television demonstrations at the exhibition) were seen by large and appreciative crowds. It is of interest to note that these demonstrations were given under normal lighting conditions prevailing on the stand.

Further, the cathode-ray tube and loudspeaker were connected to the receiver by cables 12 ft. 6 in. long, and notwithstanding this length the 2.5 Mc/s. bars on the tuning signal were clearly visible.

Experience of the inquiries during and after the exhibition has shown that one or two points were not made clear in the booklet, and it is regretted that there are some minor omissions. The following are representative of the commoner queries, and while individual replies have been sent to correspondents, it is hoped that their publication will help later purchasers of the Televisor booklet. The page references are to the booklet, and it is suggested that the notes be copied on to the pages at the appropriate places.

1. Can the range be increased?

As designed, the receiver is adequate for the service area of the transmissions. Beyond this, reception depends mainly on geographical conditions, and constructors may be able to obtain a clue from viewers in the neighbourhood. If it is felt that some additional gain is required, an extra R.F. stage can be inserted on the vision chassis and connected between V_3 and V_4.

Allowance should be made for the extra valve socket when laying out the chassis drilling plan.

2. Can one use a 12-in. cathode-ray Tube?

It is quite possible to use a 12 in. tube with no modification whatsoever.

A 12 in. (CRM.121) Mazda tube has been used in place of the CRM.92, and gave excellent results. Scanning amplitude was sufficient to cover the whole screen, but since the area of picture was larger than in the 9 in. tube, there was some loss of brightness. To compensate for this the E.H.T. may be increased, and this can be done by connecting the primary of T2 to the 250 V tapping on T3 instead of the 230 V tapping.

R.80 may also be reduced to 25 K instead of 100 K.

3. What is the function of the feeder Tubes?

These are short lead-through tubes intended for the anchoring of the coaxial feeder connexions in the vision chassis. They are soldered through the holes marked in Fig. 7c, half the tube projecting through the top plate of the chassis. The feeder cable screening may be taken through the tube (in the case of thin cable) and soldered to the tube inside the chassis, or, if thicker cable is used, the screening can be slipped back and soldered to the top end of the feeder tube, leaving the polythene to pass through. The polythene should project at least ¼ in. beyond the end of the tube under the chassis plate.

4. Which smoothing choke is which? (Parts List, p. 71)

Ch. 9 is 5 Henry 250 mA. Ch. 10 is 10 Hy.80 mA.

Some omissions have been noted in the text, the chief of which is the wire size for the coils. Some later copies of the booklet have correction slips inserted, but those who have not had these, should enter on the blank space in the diagram of Fig. 8:

Coil Winding Data

L.1 – L.7 and L.9 – L.14 are wound with 32 or 34 g. D.S.C. copper. Turns are held in place with Certofix. The tuned windings are nearest the moulded flange.

Other corrections are:

Obtaining Sound (p. 65)

Line 27 should refer to p. 39 and not p. 30

Sound Output Valve (p. 51)

The screen is shown disconnected. This should be joined to the junction of R.92 and T.4.

Vision Chassis Cross Screens (Fig. 7a)

The angle of these should be 60° and not 30° as shown.

Synchronising Diagram (Fig. 17)

The input is shown as coming from V7 anode. This should be V.8 anode.

The suppressor grid of V.12 should be connected to earth as in Fig. 18.

Vision Receiver Diagram (Fig. 6)

VISION Receiver Diagram (Fig. 6) R.5 is shown as going to H.T. It may be connected to any part of the H.T. line, but it is convenient to connect it to the H.T. point going to R.91, on the front control panel, as shown in Fig. 30.

W.I.F. N.H.B.

Editorial Note

We would like to thank readers who have written to point out some of the above discrepancies, and to apologise in advance if individual replies are slightly delayed.

We cannot refrain from giving ourselves a pat on the back by quoting from the following letter, which was the first received:

"I would like to take this opportunity of expressing my sincere admiration both for the initiative shown by ELECTRONIC ENGINEERING *in producing this television receiver for home construction, and for the technical excellence of the design itself, and I feel sure that the project will receive the support from the amateur that it deserves.*

May I also hope that all possible steps will be taken to ensure as far as possible continuity of supply of the necessary components. There are few situations more infuriating than the frustration of an eager desire to proceed with the construction by the unavailability of certain components."

This reader's queries have been answered in detail, and are among those given above. We sympathise with his complaint about components, but can only state that before commencing the design inquiries were made from the manufacturers about the availability of certain components and reassuring replies were received in every case. We would like to hear of any undue difficulties in obtaining supplies and will do our best to help readers.

YOU CAN'T STOP A MAN WITH A GOOD IDEA

"Fox be jiggered! It's Lorival I am after—*they* will be able to say whether it can be made in rubber."

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★ *While each material possesses its own characteristics, in many applications one is as suitable as the other, and in these times of scarcity it is as well to have this in mind. Firms in need of components, complete articles or packaging should seek our advice, which is based upon wide experience and specialized knowledge. We produce articles in rubber and ebonite as well as plastics, and our service includes design and manufacture.*

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D.C. Volts : 1mV to 5,000 Volts.
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The Design of Small Single-layer Coils

By A. I. FORBES SIMPSON*

Design charts relating the inductance, number of turns, and wire diameter for optimum Q for single-layer solenoid coils on formers of varying diameter

THE bibliography of coil design is immense, but rarely is the information available in a readily usable form. The experienced engineer will normally make a rapid estimate of the capacitances and inductances which will be required for a particular application, and from this start will know which of the many formulæ to apply in the evaluation of turns, wire, spacing, etc. He will also make a very fair mental estimate of the performance to be expected from the coil.

During the war, a large amount of radio development work has been performed by young graduates who at the time had not had the experience to assess quickly the magnitudes of reactances encountered in radio practice. As a result, time was often wasted in abstruse calculation or in the use of complicated Abacs. As no simple relationship exists between coil proportions and coil efficiency, further time was often wasted in several efforts to improve the coil performance. These charts are the result of an effort to combine simple design charts for inductance with the prediction of Q. A list of the symbols used is given in the centre column.

Effect of dimensions etc., on Q

The losses in a coil may be expressed in terms of:

(a) The H.F. resistance.

(b) The power factor, *i.e.*, the ratio of resistance to impedance.

(c) The ratio Q of reactance to H.F. resistance.

Of these methods of expression of the attributes of a coil, that in terms of Q is now the most usual having, over the others, several advantages which will be considered later.

The investigation of a number of solenoid coils has shown that a coil of unity length/diameter ratio with a pitch of 1.5 times the wire diameter will give not the highest possible Q for a given inductance at a particular frequency,

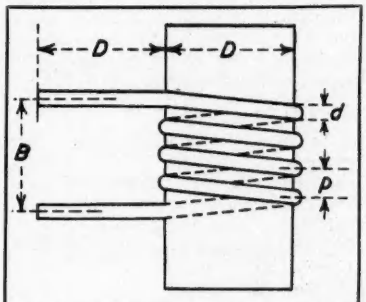


Fig. 1. Dimensions of coil referred to in text.

SYMBOLS USED

D = Diameter of former at bottom of grooving.
B = Winding length.
d = Wire diameter.
p = Pitch = $1.5d. = \frac{1}{T.P.I.}$
N = Number of turns.
$\omega_0 = 2\pi$ resonant frequency.
L = Inductance including leads.
R_s = H.F. resistance (equivalent series resistance).
C = Coil distributed capacity.
$Q = \omega_0 L/R_s$
Z_0 = Tuned impedance (dynamic resistance).
g_m = Mutual conductance.

but will give the best compromise for Q over the range of tuning capacities normally encountered. The Q for a given inductance was found to increase with the diameter of the former if the proportions were kept constant.

The law governing the relationship is dependent to some extent on frequency but is very roughly $Q^2 = k.D$.

The material of which the former is made was found to have little effect on the coil Q provided that the coil was wound on the surface, or, if wound in a groove, the grooving were no deeper than 1/5th of the wire diameter. If, however, any impregnant is used, it should be of low R.F. loss, (distrene, etc.). At the frequencies used, plated wire has shown little difference from enamelled copper.

A very real drop in Q, however, was discovered when coil tags were used in close proximity to the winding where the tags are large compared with the wire diameter. In the case of some of the finer gauges, this phenomenon was noticed until the tags were removed from the end of the winding to a distance of approximately half the winding length. For this reason termination has been by threading the wire through holes in the former in the case of wires finer than 20 s.w.g.

To obtain any required inductances while maintaining the proportions suggested above is possible, but would entail the use either of numerous former sizes or non-standard wire diameters. The cost of this method is, of course, prohibitive, and it is obvious that any method of design must cater for standard wire diameters and normally available former diameters.

To cover the spread of inductance between values corresponding to standard wire gauges, either the pitch and the number of turns could be varied keeping the coil length constant, or the number of turns and the coil length could be varied keeping the pitch constant. Of these alternatives, the latter varies the Q less, and as it reduces the values of pitch which are required, it was chosen as a method of attack.

The inductance of several coils was determined, of which the B/D ratio was unity and of which the winding pitch was $1.5d$ and the leads of which were D long. The inductances so chosen had approximately an even logarithmic spacing. These gave the basic law when plotted against wire diameter. Several coils were made similar to these coils, but the number of turns and winding length of which was different and varied from 0.6 to 1.5 of the former diameter, the values so obtained giving the relationship between turns and inductance. As

* General Electric Co. Radio Works.

these have given parallel lines, and as further random selection has not shown any appreciable error, it has been assumed that geometric completion would be justified.

The inductance limits of the charts have been fixed at the lower limit at the wire gauge at which it is difficult to bend the wire satisfactorily to the former diameter, and at the higher somewhat greater than the inductance at which a better Q is obtained from a wave-wound coil of the same overall diameter.

The use of the charts is simple and gives direct answers. As so many unascertainable factors govern the final inductance of a sited coil, no attempt has been made to achieve an accuracy better than 1 per cent. The inductances indicated by the charts assume that the leads to the coil are of the same wire as the coil and perpendicular to it, and are each a coil diameter long.

Coils of this form have a low self capacity which is largely independent of all save the coil diameter and to a lesser extent the wire gauge.

The capacity may be expressed as

$$C = D\,(.47 + a)\ \text{pF}$$

where D is in cms. and a is a constant depending on the gauge of wire, lying between .065 for 42 s.w.g. and .11 for 12 s.w.g. wire, where one lead of the coil is connected to chassis.

Use of Charts

The charts shown may be used as follows:

If the desired Q is known, then reference to the Q/L sheet will suggest a suitable diameter of former.

If, however, as great a Q as possible is required, then the largest possible former should be used unless the coil is to be sited in a can, in which case the diameter of the former should be less than one half of the internal diameter of the can and spaced from the end by the same amount or more.

When the diameter of the former is determined, reference should be made to the appropriate chart, and as shown in Fig. 2 the inductance intercept A corresponds to C, which gives the wire gauge D which gives the number of turns per inch for that gauge, and E the number of turns which are required.

It will be seen that "even" gauges of wire have been used. If it is desired to use an "odd" gauge, a little simple geometry will soon give the result.

The Q in air of a coil wound to this information, when tuned by capacities between 45 and 500 picofarads may be read directly from the Q/L curves.

The Q values shown in the chart have been corrected for coil capacity and are somewhat higher than those indicated by the useful Q meter. The accuracy of these curves is rather less than that of the inductance charts, but various values have been checked by several methods which have given substantial agreement.

Example

As an example of the use of the curves, suppose we have a variable condenser of 450 picofarads swing and desire to find a coil with which it will tune from 12 Mc/s. to 4 Mc/s. If the total capacity at 12 Mc/s. be $C\mu\mu$F then

$$\frac{C+450}{C} = \frac{12^2}{4^2} = 9 \quad \text{and} \quad C = 56.25\ \text{pF}.$$

$$\omega^2 = (2\pi f)^2 = (2\pi 12.10^6)^2 = \frac{8.10^{12}}{L.450} = \frac{1}{L.C.}$$

$$\text{and } L = \frac{8.10^{12}.10^6}{450.4\pi^2.12^2.10^{12}} = 3.15\ \mu\text{H}.$$

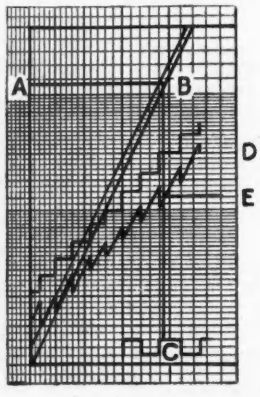


Fig. 2. Diagram to illustrate use of charts.

Self-capacity of coils of various diameters and wire sizes.

Coil Dia.	Self Capacity in pF					
¼ in.	.67	.66	.65	.64	.63	.62
⅜ in.	.82	.81	.80	.78	.77	.76
½ in.	.98	.96	.95	.94	.93	.92
⅝ in.	1.15	1.14	1.13	1.12	1.10	1.09
Wire size	12 s.w.g.	18 s.w.g.	24 s.w.g.	30 s.w.g.	36 s.w.g.	42 s.w.g.

Inspecting the Q/L charts we see that the Q at 4 Mc/s. will lie between 116 for ½ in. and 168 for a ⅞ in. former, while that at 12 Mc/s. will lie between 182 for a ½ in. and 265 for ⅞ in. former.

If we choose a ⅝ in. former we find that the line corresponding to this cuts the L line at 0.025 in. This line intersects *T.P.I.* at 23.8 and the "No. of turns" are 18.5 with a wire gauge of 22 s.w.g.

Referring to Q/L Sheet—we find for $L = 3.15\ \mu$H:

C. pF	45	100	200	400	500
"Q"	212	195	175	150	142

Z_o is readily obtained by writing

$$Z_o = Q\sqrt{\frac{L}{C}}$$

If, however, we had used the ½ in. former we would find that 18 turns of 26 s.w.g. at 37 *T.P.I.* would give

C. pF	45	100	200	400	500
"Q"	181	165	147	123	117

It was mentioned earlier that the expression of the performance of a coil in terms of Q had several advantages over other methods.

The response of a tuned circuit may be expressed in terms of Q and resonant frequency.

If δ be the deviation from resonance expressed as a percentage of the resonant frequency, and S be the response, at that deviation expressed as a percentage of the resonant response, then

$$S = \frac{100}{100 + \delta + \text{j}.Q.\delta\left(\frac{2+\delta}{1+\delta}\right)}$$

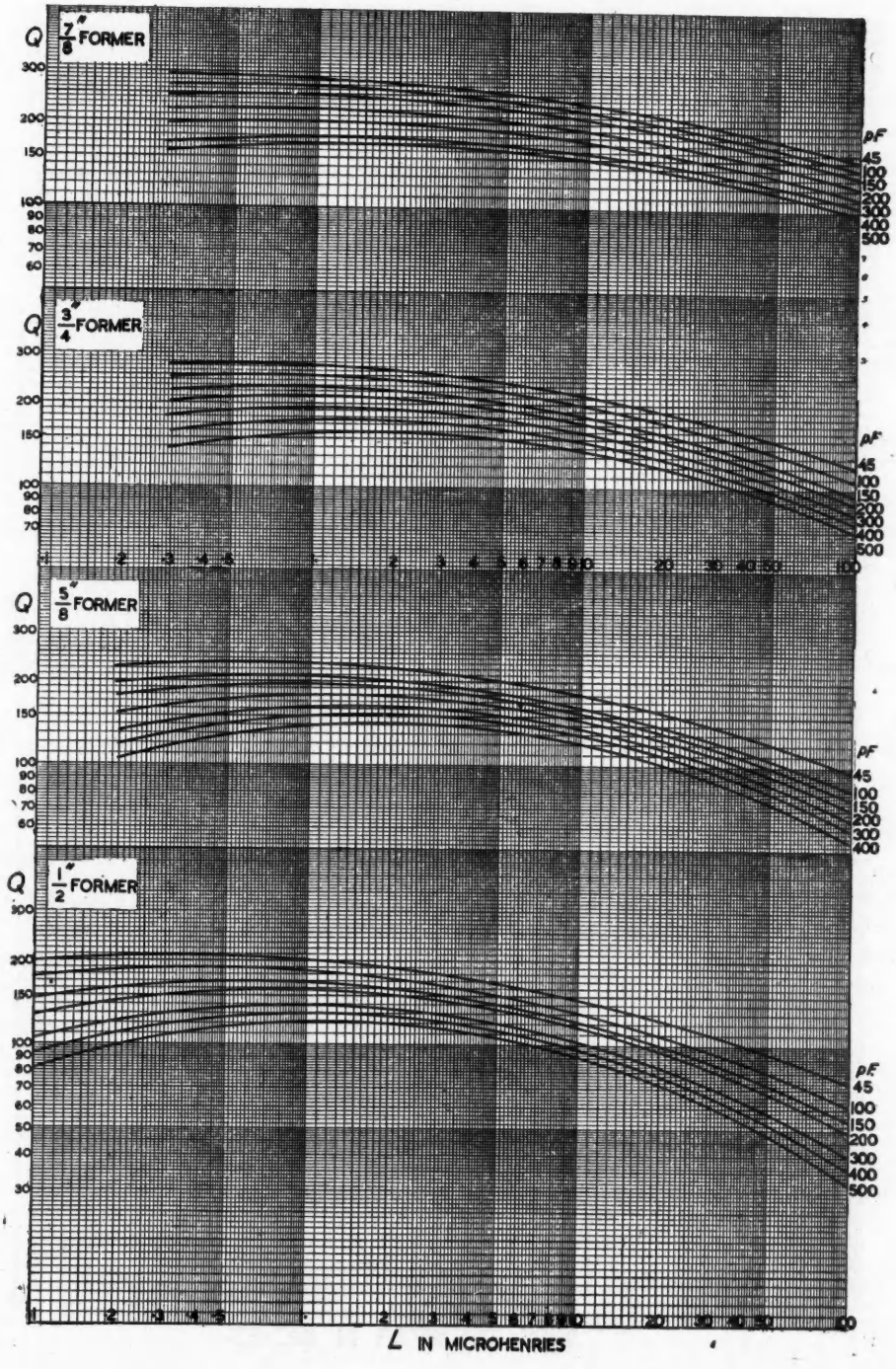
One curve may therefore be used to determine the selectivity of all tuned circuits of which these attributes are known. "The Universal Selectivity Curve" corresponding to this expression has been published in many forms.

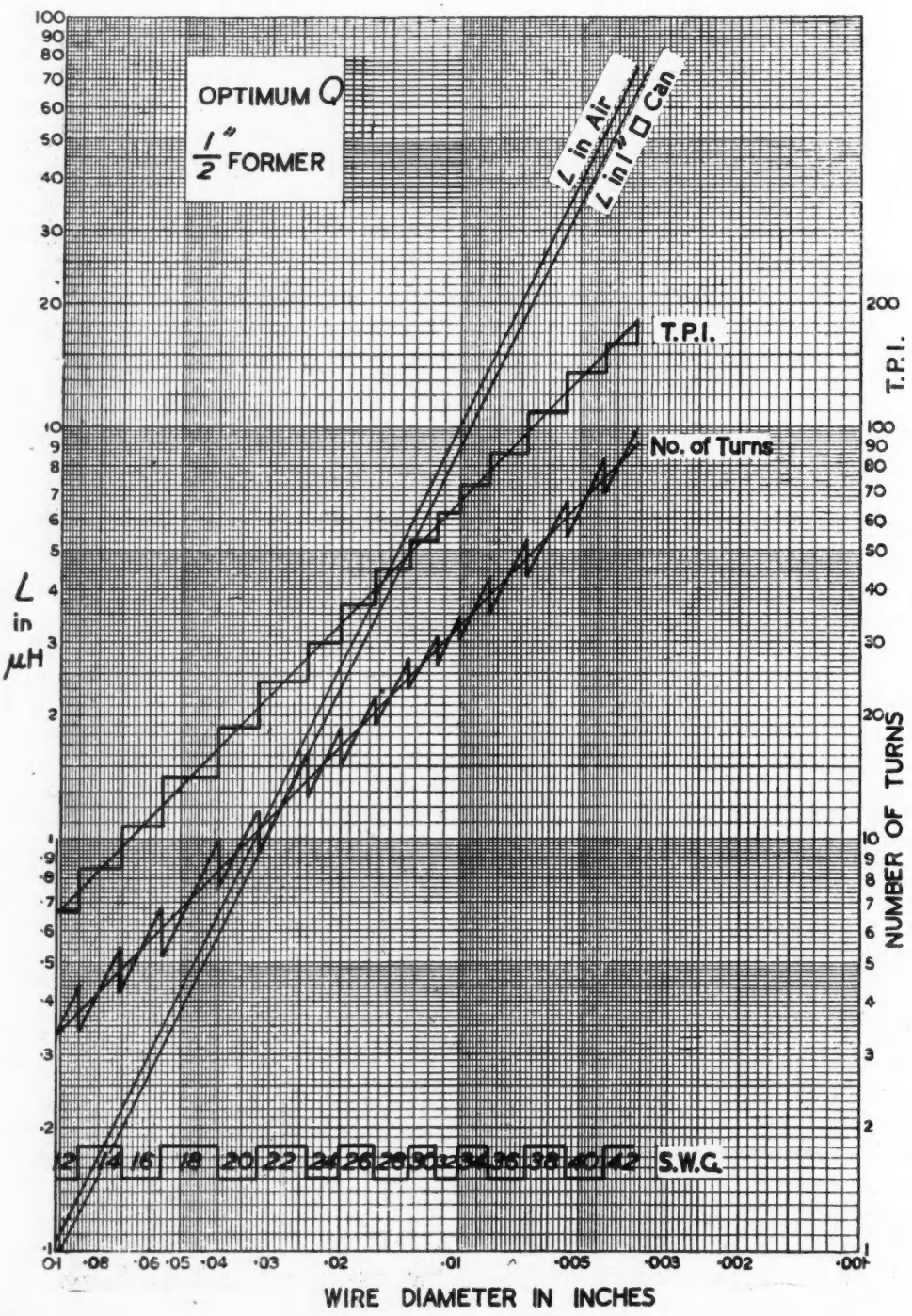
Where the Q of a circuit is known, and within the limits of these curves one may normally assume that the coil Q approximates to this, it is possible to evaluate quite readily:

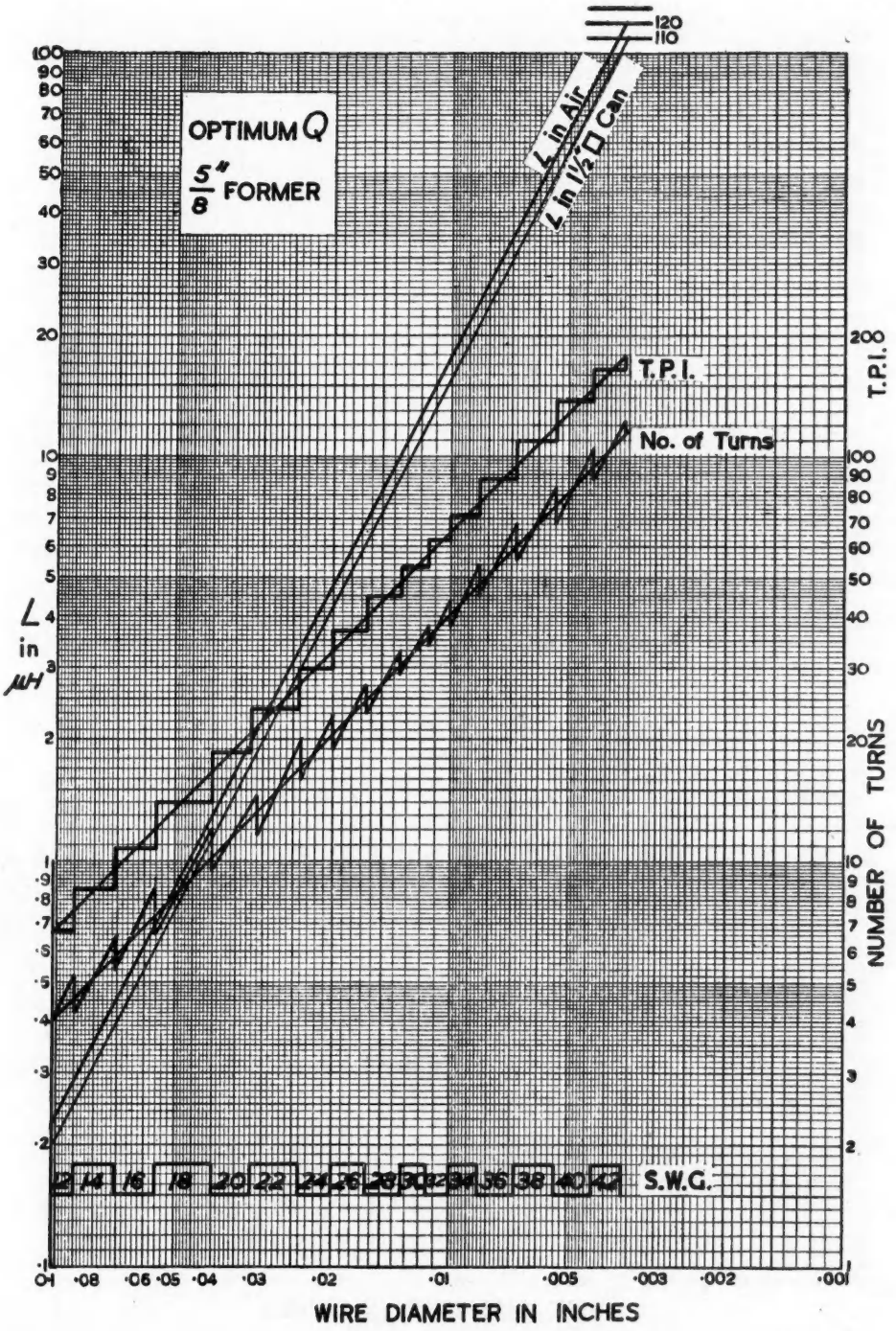
(a) The tuned impedance (dynamic resistance).

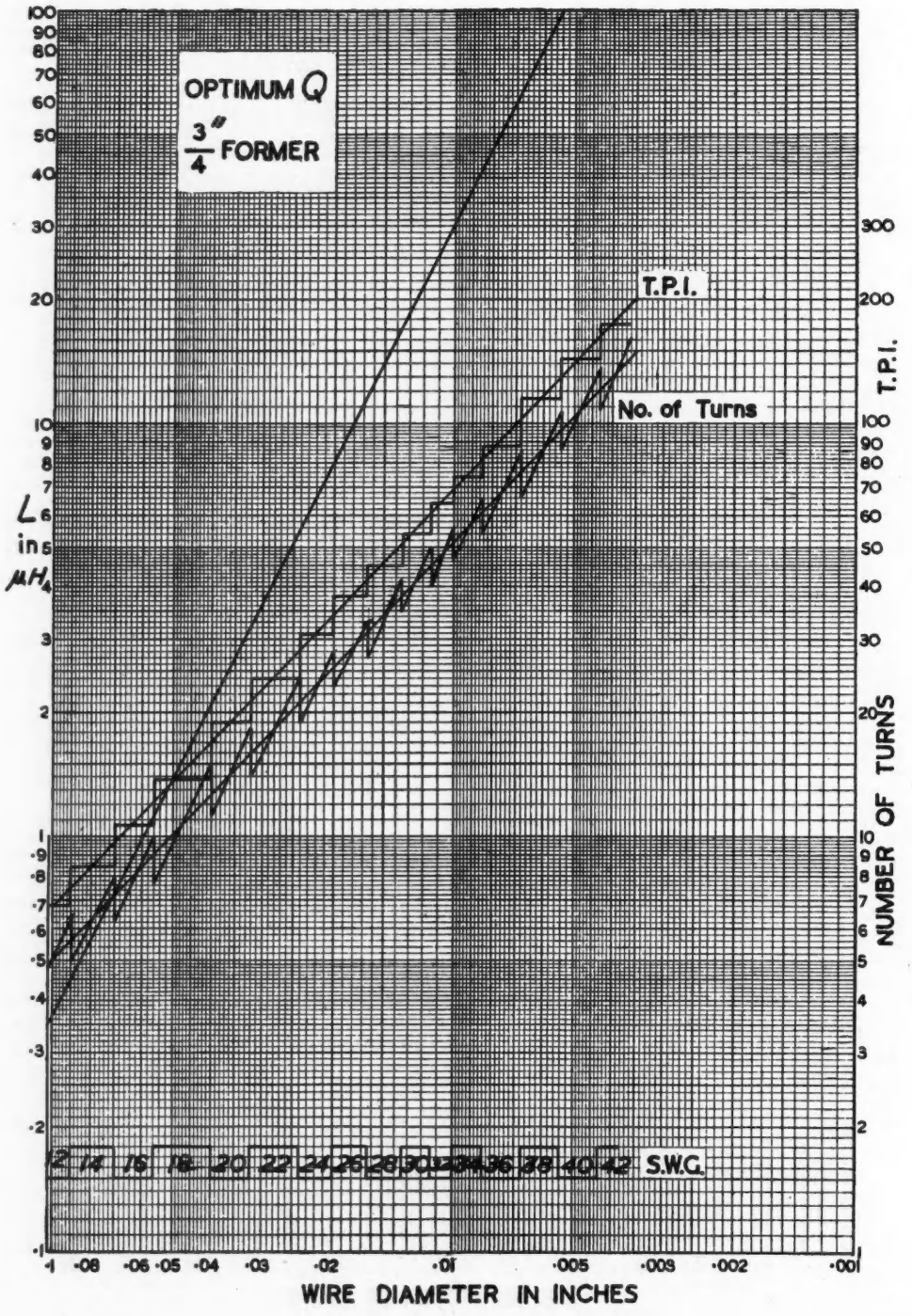
(*Continued on p.* 360)

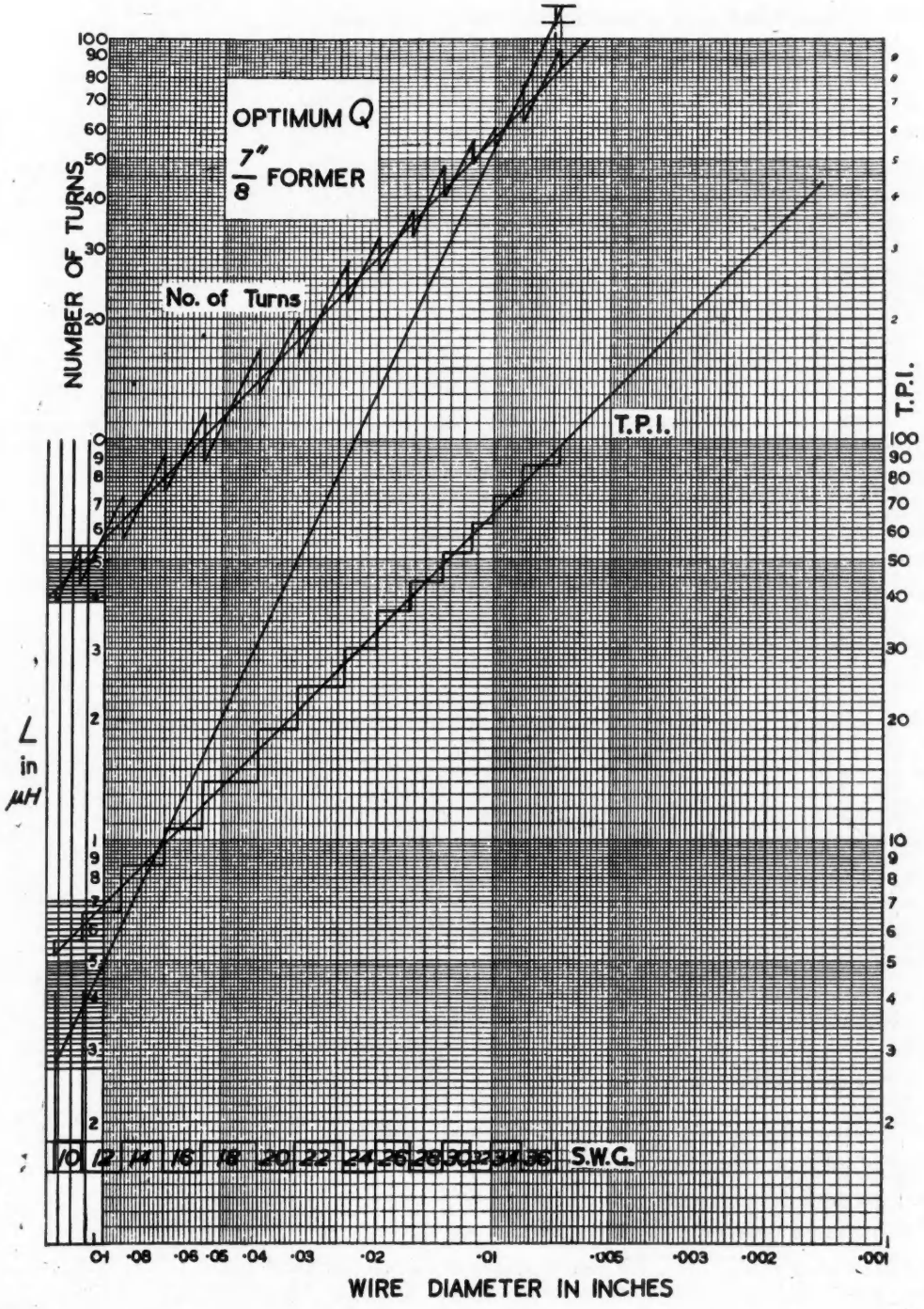
Q/L Chart for obtaining suitable size of former



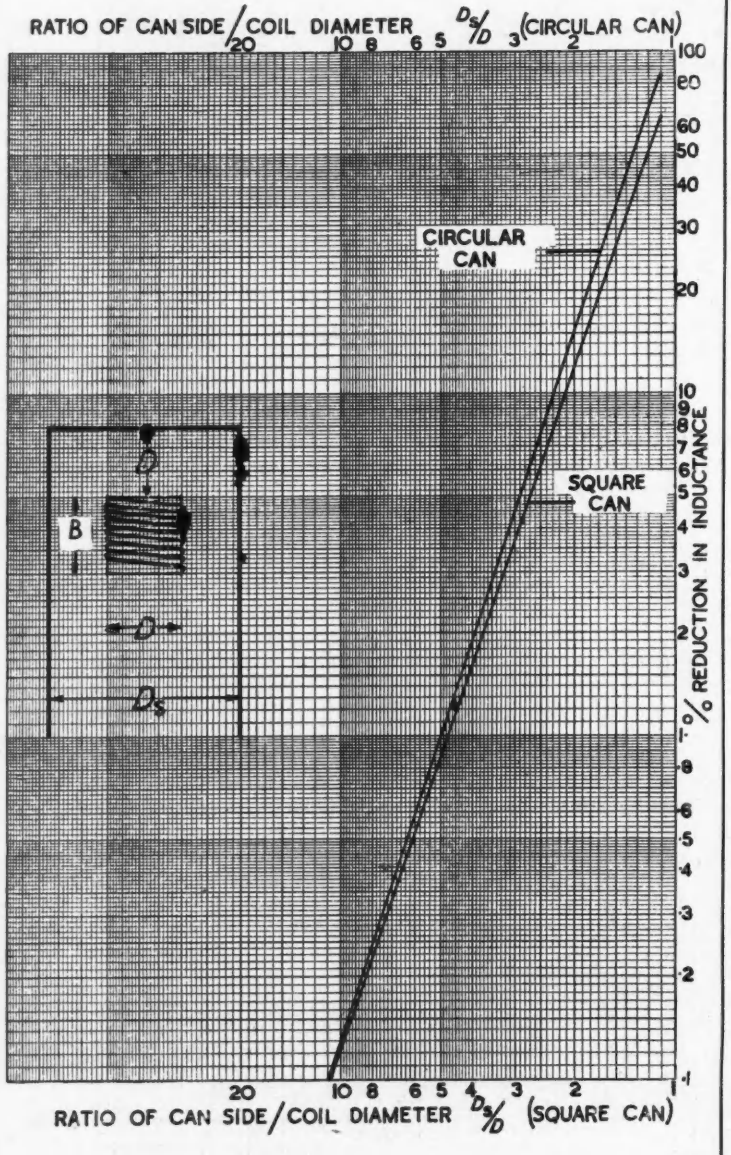

OPTIMUM Q
1/2" FORMER
L in Air
L in ½" □ Can
T.P.I.
No. of Turns
L in μH
T.P.I.
NUMBER OF TURNS
S.W.G.
WIRE DIAMETER IN INCHES


OPTIMUM Q
5/8" FORMER
L in Air
L in 1½ □ Can
T.P.I.
No. of Turns
L in μH
NUMBER OF TURNS
S.W.G.
WIRE DIAMETER IN INCHES


OPTIMUM Q
3/4" FORMER
T.P.I.
No. of Turns
L in μH
T.P.I.
NUMBER OF TURNS
12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 S.W.G.
WIRE DIAMETER IN INCHES


OPTIMUM Q
7/8" FORMER
No. of Turns
NUMBER OF TURNS
T.P.I.
L in μH
S.W.G.
WIRE DIAMETER IN INCHES

Effect of Circular and Square Screening cans on Inductance


RATIO OF CAN SIDE/COIL DIAMETER Ds/D (CIRCULAR CAN)
20 10 8 6 5 4 3 2 1
100 90 60 50 40 30 20 10 9 8 7 6 5 4 3 2 1 ·8 ·6 ·5 ·4 ·3 ·2 ·1
% REDUCTION IN INDUCTANCE
CIRCULAR CAN
SQUARE CAN
B
D
Ds
RATIO OF CAN SIDE/COIL DIAMETER Ds/D (SQUARE CAN)

The reduction in inductance of a coil of unity B/D ratio when sited in a screening can.

The Design of Single-layer Coils

(*Continued from p.* 354)

(b) The stage gain.

(c) The conditions for maximum stable gain.

(a) The tuned impedance may be expressed as:

$$Z_o = Q.\omega_o.L = \frac{Q}{\omega_o.C} = Q^2.R_s = Q\sqrt{\frac{L}{C}}$$

It will be seen that since ω_o and L or C are normally accurately known, Z_o is readily ascertainable.

(b) Where the tuned circuit is used as an anode load, the ease with which the stage gain may be computed depends on how many terms may be neglected.

Normally, the valve used in an R.F. amplifier is a pentode and the approximate amplification is given by:

$$M = g_m \frac{Q\omega_o L}{1 + \frac{Q\omega_o L}{R_1}}$$

where R_1 is the sum of shunt loads, *i.e.*, grid leak.

If a critically coupled tuned transformer is used, it should be noted that the effective Q is halved, and for other degrees of coupling, (N times critical) the effective $Q_1 = \frac{Q_2}{N^2 + 1}$ where Q_2 is that obtained with the secondary removed of short circuited.

(c) the condition for stable gain may be given in the form that $H < K$, where, Z_{oa} and Z_{og} being the anode and grid impedances,

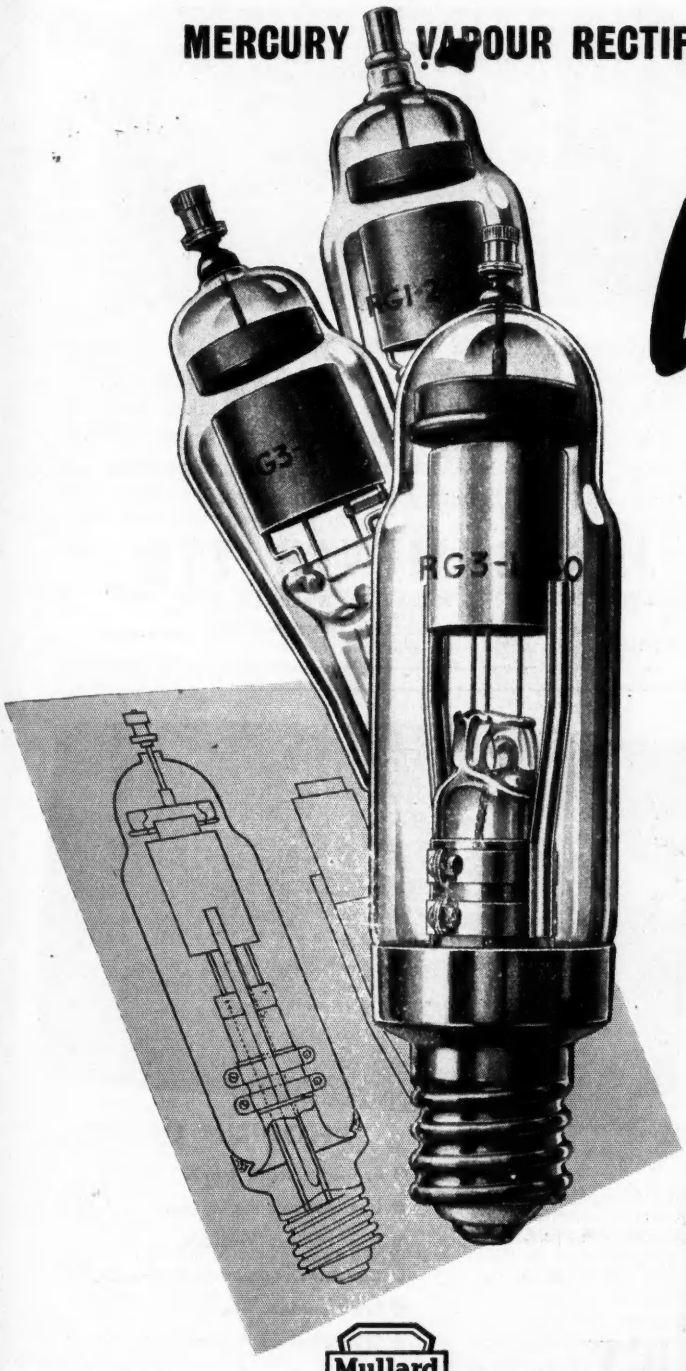
$$H = g_m.\omega_o.C_{ag}.Z_{oa}.Z_{og},$$

and K is a constant, being 2 for an ideal stage.

Empirical values of K for other conditions are tabulated below:

	No. of Amplifying Stages			
Condition	1	2	3	
Ideal	2	1.5	1	
Normal	1	0.75	0.5	K
Critically coupled transformer coupling	0.5	0.375	0.25	
Normal single T.Ct. with ganged condenser	0.25	0.188	0.125	

MERCURY VAPOUR RECTIFIERS WITH AN ASSURED



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RG1-240A

Peak Inverse Voltage	4,700 V
Mean Anode Current	250 mA max.
Two Valves in a Single-Phase Full-Wave Circuit will give 1,500 Volts at 500 mA.	
Filament Voltage	4.0 V
Filament Current	2.7 A

RG3-250

Peak Inverse Voltage	10,000 V
Mean Anode Current	250 mA max.
Two Valves in a Single-Phase Full-Wave Circuit will give 3,150 Volts at 500 mA.	
Filament Voltage	2.5 V
Filament Current	5.0 A

RG3-1250

Peak Inverse Voltage	13,000 V
Mean Anode Current	1.25 A max.
Two Valves in a Single-Phase Full-Wave Circuit will give 4,140 Volts at 2.5 amps.	
Filament Voltage	4.0 V
Filament Current	7.0 A

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Mullard

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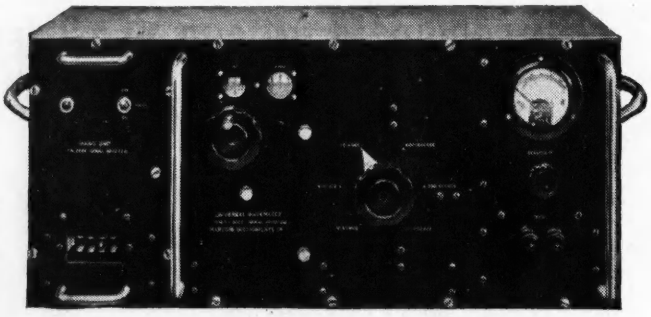
TYPE TF 370F

Brief Specification:

Frequency Range: 100 kc/s - 20 Mc/s by means of Calibration Charts.

Accuracy - - - - 1 in 10^3

Full Specification supplied on request



The Wavemeter is of the resonance type and consists of an adjustable tuned circuit shunted by a high impedance valve voltmeter, the input to the tuned circuit being taken via a two-stage amplifier of variable gain. The power supply may be taken either from A.C. mains or from external batteries. Workmanship is in the highest Marconi tradition.

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The Physics of Industrial Diathermy—*Part 3*

By A. W. LAY, A.M.I.E.E., F.Inst.P.*

IN comparison with orthodox heating methods the advantages of high-frequency technique may be summarised thus:

As compared with Hot Plate Glueing

(a) The temperature is uniformly distributed.
(b) Time is usually greatly reduced for all except thin sections.
(c) Much thicker sections can be glued.
(d) Higher temperature glues can be used.
(e) Temperature can be more closely controlled.
(f) The surface of the wood is not dried out before the interior.

Advantages of R.F. compared with Cold Glueing

(a) Very large reduction in time cycles.
(b) It allows of the use of phenol glues.
(c) Makes for better and more consistent joints.
(d) Requires fewer presses or jigs.
(e) Results in large saving in floor space.

Advantages of R.F. in Making Plywood

(a) Reduction in the overall time cycle.
(b) The number of dies needed is less.
(c) Great reduction in internal stresses.
(d) Facilitates close control of temperature.
(e) Operations are less critical.
(f) There is less likelihood of exothermic reaction.
(g) Gives greater latitude in design.

The problem now becomes one of radio engineering design.

It may be added that for some applications of H.F. heating technique which involve the use of plate type of applicators, it may be found convenient to arrange two outer plates in parallel at earth potential, and a third mid-way in the space between them. This third plate is active at full R.F. potential.

Between the two spaces thus formed the wood, or other kind of work, such as plastic, form the dielectric of the two condensers in series thus constituted.

The effective capacity and resistance of such an applicator system can be easily calculated from well-known laws.

* Marconi Research Dept.

Case Hardening

The application of H.F. technique is being extended to many industrial heating processes. They are already too numerous to detail here; but a few of the more important ones should be mentioned.

It is well known that low-frequency induction has been in use for many years in the process of melting and heating metals before forging them.

Our interest here is in the recent developments in the application of the skin effect produced by high-frequency currents in conductors.

A full analysis of this requires the use of Bessel functions; but for the present purpose it may be stated that when a cylinder is heated by high-frequency current over 90 per cent. of the heat is generated in a peripheral layer whose thickness is t cms., and which is small compared with the radius of the cylinder. On these asumptions t is given thus:

$$t = \frac{1}{2\pi}\sqrt{\frac{10^9\rho}{\mu f}} = 5{,}030\sqrt{\frac{\rho}{\mu f}} \quad \ldots (54)$$

*ρ is the resistivity in C.G.S. units, μ represents permeability, and f the frequency in c/s.

For carbon steel at room temperature the thickness of the layer is about

$$20/\sqrt{f} \text{ cms.} \quad \ldots (54A)$$

At the Curie point of about 790° C. the permeability suddenly falls to unity as indicated in Fig. 13.

At this point there is an increase in resistance. The layer thickness t of the heated ring is then

$$t = \frac{500}{\sqrt{f}} \text{ mm.} \quad \ldots (54B)$$

For example, if f is 1.0 Mc/s. the effective skin thickness of steel is about 0.002 cms. at 20° C. and 0.05 cms. at the Curie point.

The production of an outer concentric ring of heat is almost ideal for case hardening where it is desired to produce a hard outer skin, or case, in steel, while at the same time allowing the core of the body of the steel to retain its original properties of toughness and tensile strength.

From what has been written already concerning temperature gradients it will be appreciated that a steep gradient is momentarily established between the outer ring of heat and the centre of the steel body.

This material, however, is a good thermal conductor, and hence it follows that there will be a rapid flow of heat from the outer ring of heat to the centre unless the former is produced rapidly and the article quenched in a cooling medium, such as a fluid, before time has been allowed for thermal conduction to level up the temperature gradients.

It has been found in practice that a heating period of 0.6 to 1.0 sec. between the initial heating and quenching is satisfactory.

In order to accomplish this a power concentration of 1,000 watts per sq. cm. of surface is necessary.

Analysis shows that the power absorbed in a metal body at constant current in a heating coil varies with the square root of the product of its permeability and resistivity, in accordance with the expression:

$$P \propto \sqrt{R\mu} \quad \ldots (55)$$

For some practical purposes it is useful to have an idea of the temperature distribution in the body. This is is indicated by an equation due to Frankel, which takes the form of a convergent series when expanded; but it is too lengthy to set down here.

This series indicates that the temperature at the point under consideration is a function of an empirical constant; of the wall thickness; of the distance of the point from the surface; and of the time in seconds.

The loss of heat due to radiation from hot bodies is indicated in Fig. 14.

If the steel article is thick, or of large radius, a greater thickness, t, of the hardening can be allowed, since there would be ample steel left for the tough core. In this case a much lower frequency may be used, as indicated in Equation (54).

This subject may be summarised by stating that by using high-frequency technique:

Frequencies of from 50 Kc/s. to 50 Mc/s. have been used; but the most useful range is from about 5 Mc/s. to 15 Mc/s. In this range up to 75 KW of H.F. power has been found necessary for some purposes.

This is also very useful for dielectric heating technique.

* ρ in C.G.S. units = specific resistance: cm^3 × 10^9

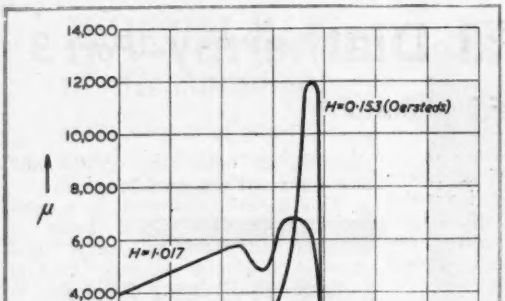


Fig. 13. Curve showing change of permeability with temperature in carbon steel.

In Part I of this series (p. 292 September issue) Figs. 7 and 8 were wrongly attributed to J. W. Taylor.

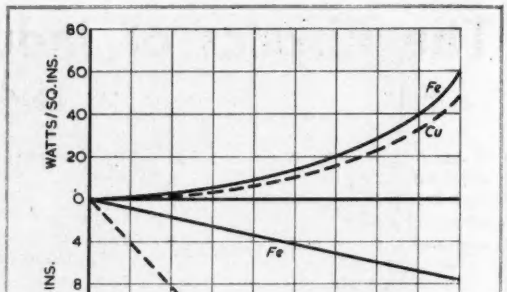


Fig. 14. Upper curves give the loss from heated metal by surface radiation to air at 75° F. Lower curves: Conduction through ½ in. metal wall to water at 75° F. At 1600° F. the surface loss by natural conduction is 5 KW/sq. in. of surface to a layer ½ in. below the surface.

Tinning Steel Plates by H.F. Heating Technique

Until recently steel plate has been tinned by what is known as the hot dip process.

This was not very economical either in time or tin, as by this method the steel plates had to be treated individually, and about 1.5 lb. of tin was applied to each 100 lb. of steel plate.

Whatever process is used to tin steel plate it is essential that the final finish shall be a uniform mirror-like surface in order to resist corrosion.

This necessitates the tinning being melted at a temperature of 450° F. and thus caused to flow uniformly and produce the required finish.

High-frequency heating technique is ideal for this purpose, and offers many advantages over the processes hitherto employed.

It has been found possible in practice to run long lengths of steel plate through the plating bath and then finish by passing them through the field of an induction heating coil which raises the tin to its melting point; thus causing the flow which produces a uniform mirror-like finish.

By using this process only about 0.5 lb. of tin is required per 100 lb. of steel plate. The final thickness of the tinning is only about 0.00003 in. thick.

The economy in this expensive commodity is rendered possible by the uniform skin heating effect produced by high-frequency current.

Steel plate used for tinning is usually 0.010 in. thick, and 28 to 36 in. wide. The new process facilitates a continuous flow of steel plate along a line to the tinning and finishing plant. It is uncoiled from rolls containing 2 or 3 miles of untinned plate, and fed to the plant at a rate as high as 500 ft. per min.

The skin effect of applying high-frequency current to conductors has already been considered. This process depends on that principle.

We can apply the general laws of the physics of heat to the process.

The specific heat of steel strip is 0.12, and its density 7.82 grams per c.c. Knowing this, the melting point of tin being 450° F., and the dimensions of the strip, we can calculate the power required to melt the tin. If this is P in KW we have:

$$\text{KW} = 3 \times v \times b \times t \quad \ldots\ldots\ldots (56)$$

v is the speed of the plate along the line in feet per minute, b the width of the plate, and t thickness, both in inches.

Now we have seen already that if the frequency of the high-frequency field is high enough that the current will be concentrated in a thin surface layer, and therefore the main body of the strip will not carry current.

As stated already, space does not permit of the use of Bessel functions to deal with the heating effect, so we give an approximate equation due to Rosenberg for the eddy current loss W in watts per sq. cm. of surface:

$$W = 2\sqrt{\rho f T^2 B} \times 10^{-4} \quad \ldots\ldots\ldots (57)$$

ρ is resistivity in ohms/cms.; f the frequency in c/s.; T the root mean square ampere turns per cm. of magnetising force at the surface of the plate. B is the saturation flux density in gausses.

This expression assumes that f is high enough to give a thin skin of current and that the magnetising force is more than sufficient to produce magnetic saturation.

If we assign a saturation flux density of 18,000 gausses in the steel strip, of which the resistance is 15 micro-ohms per cm.[3] then, if the dimensions of the strip are inches, we have:

$$P = 3.307\ (1/t) \times \sqrt{f T^3} \times 10^{-4} \quad (58)$$

where P is the rate of heating of the strip, in watts per cu. in., within the temperature range from the natural ambient temperature of the room to 450° F. The other symbols retain their significance.

Now Equation (58) gives us the total power required to heat the volume of tinned plate, which is constituted by t, b, and the rate of feed of v ft. per min. This must be equal to the volume of strip within the inductor coil and the rate of heating per unit volume. Hence the length of the inductor coil to heat the tinned strip to 450° F. will be:

$$l = 3 \times v/p \times 10^3 \quad \ldots\ldots\ldots (59)$$

where l is the length of the inductor coil in inches.

This coil can be energised by a self-excited push-pull oscillator fed from a rectified supply.

(*Continued on p. 364*)

The Application of Chemically Unstable Phosphors to Cathode Ray Tubes

By R. B. HEAD, M.Sc., (London)*

IT has long been known that the use of many phosphors for cathode-ray tube working has been prohibited on a number of grounds. Among these phosphors may be mentioned the alkaline-earth oxides, sulphides, selenides and tellurides. The alkaline-earth oxides cannot exist in the presence of water owing to the immediate formation of hydroxide, and the subsequent absorption of carbon-dioxide from the atmosphere. The stability of the other compounds varies somewhat, but on exposure to a moist atmosphere, sulphuretted, seleniuretted and telluretted hydrogen can be detected. These gases are toxic, and the phosphors from which they are released, soon become spoiled, unless the necessary precautions are taken. The oxides are strong alkalis, and good desiccating agents, so good in fact, that they tend to "steal" water from less powerful desiccants such as silica-gel. Owing to the relatively short distance of electron penetration at low voltages, the efficiency of some phosphors is materially decreased after an exposure of only three or four minutes to the atmosphere, since the crystals become superficially covered with layers of non-luminous reaction-products. Although a considerably higher beam-voltage is then necessary to excite fluorescence, a much smaller loss of efficiency is often noted under ultra-violet excitation.

Unstable materials may be roughly grouped into three classes:

(1) Materials which cannot be exposed to the atmosphere for more than three or four minutes. (SrO, BaO).

(2) Materials which can be exposed to air for at least an hour. (CaO, SrS, SrSe).

(3) Materials, such as certain sulphates, which though soluble in water, do not show appreciable hygroscopicity.

It is clear that the materials in (1) and (2) cannot be applied to the surfaces of cathode-ray tubes by the use of the more common binding agents, or by any method wherein the binder contains any substantial amount of water. Attempts to "settle" the phosphor crystals in organic media such as acetone fail firstly because it is virtually impossible to prepare perfectly dry acetone, and secondly, because even "well-dried" acetone soon absorbs an appreciable quantity of water in contact with the atmosphere. In any case, the construction of a cathode-ray tube containing an unstable phosphor presents other difficulties since the application of the conducting coating is often carried out by a wet method. The writer has found that if the tube is completed up to the "sealing on" stage, and the screen applied by a specially developed method immediately before sealing on, very serviceable tubes can be made employing the most unstable types of phosphors. This special method forms the subject matter of British Patent No. 586524 in the joint names of the author and Cinema-Television, Ltd. During the application of such a screen, the delay between the unsealing of the phosphor sample, and the commencement of pumping has been reduced to as little as a hundred and fifty seconds. The effectiveness of this new method of applying screens lies both in the fact that the particles are anchored only at one point (a general suggestion to this effect regarding stable materials was made by Levy and West in their 1936 paper, read before the I.E.E.), and also in the fact that single-crystal-layer screens are formed. In cases where the screen is directly activated by cathode-rays, the single-crystal-layer can be a condition for maximum efficiency, providing the electron penetration at the working voltage is small compared to the depth of a single crystal.

Several binders may be used with unstable materials, the most important of these being phosphoric acid. The amount used is about 0.00001 grms./sq.cm., or less than one-thousandth of the weight of luminescent material to be applied. The phosphoric acid is heated electrically on a platinum spiral, where it evaporates freely at temperatures in the neighbourhood of 1,100° C., and recondenses a short distance away to form a smoke or fog of droplets. This smoke is then blown into the glass envelope of the cathode-ray tube, and allowed to settle for a short time upon the surface to which the screen is to be applied. The excess smoke is then blown away, leaving a very fine deposited mosaic of droplets upon the surface. The mosaic is usually invisible unless examined microscopically, and is thus totally different from the coarse condensation mosaic formed where vapours are allowed to condense directly upon surfaces. A suitable quantity of a phosphor poured over the mosaic will now adhere to form a layer one particle thick, the excess powder being removed by vibrating the surface. The phosphoric acid trace attacks many phosphors in the cold, and on baking, glass carriers are somewhat attacked, the binder now existing as a mere trace of reaction product. The bombarded surfaces of the particles do not, of course, come into contact with the phosphoric acid. The process is of use with stable as well as unstable materials, but since an excess of phosphor is removed by vibration, it will be apparent that the percentage area of the screen covered with material, and thus the luminous efficiency, will depend upon the physical properties of the material, its size-frequency distribution, and the number of times the phosphor is poured across the surface of the screen.

True hexagonal packing does not occur in a single-crystal-layer, since it is always necessary to deal with a range of shapes and sizes of particle. Experiments with well-crystalline substances, such as the coarser sulphides show that a superficial coverage-factor of 0.9 may be reached. It is clear, however, that it is not possible to fill all the gaps between the first layer of deposited crystals by continuous rolling of a powder across a mosaic. While such a procedure does improve the coverage-factor it encourages the formation of aggregates, unless the physical properties of the phosphor are exceptionally good. The best screens have been made from phosphors possessing steeply rising size-frequency distributions, which cut off rather sharply in the fines. In this case, a greater number of fine particles exist which

*Cinema-Television Limited.

are suitable for filling gaps between the larger crystals. It is not possible to construct screens in which the crystals are placed extremely close together in one pouring operation, because the crystals at the edge of a sliding pile are often forced to rotate through a considerable angle before a facet contacts the mosaic. The use of particles of less than 0.01 mm. maximum linear dimension presents a good deal of difficulty since the surface forces, very much in evidence, tend to prevent complete removal of the excess phosphor from the single-crystal-layer. The successful application of very fine powders thus depends on the skill and experience of the operator, whereas little skill is required where the particle size is larger.

During the formation of a crystalline material at a high temperature, a struggle takes place between the forces of surface-tension and those of crystallisation. This often results in the smaller crystals becoming rounded, so that the crystal faces are poorly marked, or even apparently absent. Particles of this sort, as well as irregular masses of interpenetrating crystals cannot be made to adhere very strongly to mosaics unless the particle size is small. The adherence of some stable materials, zinc and zinc-cadmium sulphides is so strong after baking, that the particles are not removed by concentrated hydrofluoric acid, and in some cases can only be removed by dissolving them *in situ* by the use of hot concentrated aqua-regia.

The preparation of some of the oxide phosphors occasionally gives difficulty. Where the phosphor is manufactured from a nitrate or hydroxide, which fuses before solidifying, an extremely hard cake of material often forms, which may defy crushing. The writer has found that if the material is heated from the top only (by radiation), in a tall crucible, the last traces of water which are expelled cause the material to expand, forming a loose froth, which after calcination at temperatures as high as 1,450° C., easily falls to a crystalline powder on gently stirring with a rod of alumina. It is thus possible to prepare unstable phosphors of considerably improved physical properties. (Patent pending.)

The following sequence of operations will provide some idea of the construction of a cathode-ray tube containing an unstable material:

(1) A tube complete with gun, conducting coating, and an extra side arm is supplied to the operator.

(2) Operator admits phosphoric acid suspension via side arm, allows to settle, and blows out excess.

(3) Operator unseals phosphor sample, and introduces requisite quantity of powder via the side arm.

(4) Operator commences to pour the phosphor over the mosaic, and his assistant immediately seals up phosphor sample and places in dessicator. Starts backing pump.

(5) Operator vibrates screen to remove excess powder, and removes excess via side arm by manipulation.

(6) Glass-blower seals up side arm, seals tube on to vacuum system, and opens vacuum tap.

It is seen that this technique requires the use of considerable precautions, and a certain amount of trouble. The screen quality consistently obtained with some materials, however, is at least equal in uniformity and grainlessness to that obtainable with good single-crystal-layer sulphide screens, and it is to be hoped that some materials, which remain of merely academic interest at the moment, will become of general use.

The Physics of Industrial Diathermy

(*Continued from p. 362*).

At present the frequency in use for this process is 200 Kc/s., and several units, each generating 200 KW of high-frequency power, are installed in some plants.

The design of the high-frequency equipment follows orthodox practice.

In addition to the applications of high-frequency technique already mentioned the following are only a few of the many developments.

The manufacture of laminated plastic materials. Fusion, or joining thermoplastic materials together. Drying of rayon yarn; paper; textiles; powders, ceramic clays; oxides, such as alundum and carborundum; tobacco; and edible matter. The thermogenic properties of high-frequency currents are valuable in accelerating cooking and baking processes; and can be used to destroy infestation in grain and cereals generally, also in accelerating chemical reactions.

Of General Interest in Industrial Applications of H.F. Power is the Screening Problem

The laws of E.M. radiation and the technique of screening are sufficiently well known as to need no detailed discussion here, but it may not be out of place to mention that since radiation is a function of the radiation resistance and current external to the R.F. generator, and as the radiation resistance is proportional to the square of the ratio between the distance separating the current carrying conductors and the working wavelength, a special problem arises in the application of heat frequency to woodworking processes.

Some problems may be met in this technique where the specification requires a high power set capable of dealing with a large volume of wood per charge of the applicator, and that the thickness of the stack of wood may be such that the thickness causes the applicator plate spacing to be a considerable fraction of the working wavelength.

The efficiency of the applicator system as a radiator will be appreciated.

This problem is best solved by installing the whole equipment in a screened building in accordance with B.S.I. Specification CJ(ELE) 760. CP: 1947.

No doubt forthcoming legislation will allocate specific frequencies for non-communication equipment, and decree that all such apparatus must be operated in an efficiently screened enclosure.

Correction to Part 2.

Unfortunately some printer's errors made nonsense of the mathematical reasoning in calculating the rate of heat generation on p. 290, September issue, although the final result was given correctly.

The intermediate steps should have read as follows:

$$H \quad dy.dz.dx.dt = s.m\ (\partial\theta/\partial t)\ dy.dz.dx.dt$$

$$+k\,.\,dy\,.\,dz\,.\,dt\left[\left(\frac{\partial\theta}{\partial x}\right)_{\mathrm{p}}-\left\{\frac{\partial}{\partial x}\left(\frac{\partial\theta}{\partial x}\right)\right\}\frac{dx}{2}\right.$$

$$-k\,.\,dy\,.\,dz\,.\,dt\left[\left(\frac{\partial\theta}{\partial x}\right)_{\mathrm{p}}+\left\{\frac{\partial}{\partial x}\left(\frac{\partial\theta}{\partial x}\right)\right\}\frac{dx}{2}\right.$$

$$+k\,.\,dx\,.\,dz\,.\,dt\left[\left(\frac{\partial\theta}{\partial x}\right)_{\mathrm{p}}-\left\{\frac{\partial}{\partial x}\left(\frac{\partial\theta}{\partial x}\right)\right\}\frac{dy}{2}\right.$$

$$-k\,.\,dx\,.\,dz\,.\,dt\left[\left(\frac{\partial\theta}{\partial x}\right)_{\mathrm{p}}+\left\{\frac{\partial}{\partial x}\left(\frac{\partial\theta}{\partial x}\right)\right\}\frac{dy}{2}\right.$$

$$+k\,.\,dx\,.\,dy\,.\,dt\left[\left(\frac{\partial\theta}{\partial x}\right)_{\mathrm{p}}-\left\{\frac{\partial}{\partial x}\left(\frac{\partial\theta}{\partial x}\right)\right\}\frac{dz}{2}\right.$$

$$-k\,.\,dx\,.\,dy\,.\,dt\left[\left(\frac{\partial\theta}{\partial x}\right)_{\mathrm{p}}+\left\{\frac{\partial}{\partial x}\left(\frac{\partial\theta}{\partial x}\right)\right\}\frac{dz}{2}\right.$$

A New Double Electrometer Valve

By G. C. LITTLE *

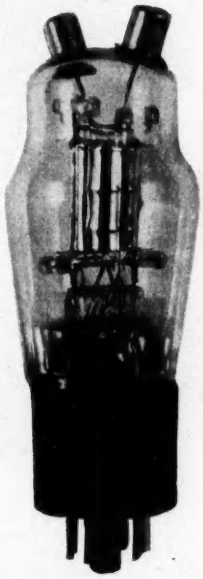
SMALL electrical currents of the order of 10^{-15} amperes may be measured by means of circuits using the so-called Electrometer Valves. These are thermionic valves, usually triodes or tetrodes, with very high input grid insulation (of the order 10^{13} to 10^{16} ohms). The maximum sensitivity of such circuits is, however, limited by fluctuations in the supply voltages and in the filament emission of the valves.

Several workers, notably Brentano[1] and Wynn-Williams[2] have described balanced bridge circuits, using two valves in which the effects of fluctuations in battery potentials may be eliminated. These circuits, however, do not compensate for random fluctuations in the emission of the individual valves, such as might be caused by the slow poisoning or activation of one of the filaments.

This latter point was overcome by DuBridge and Brown[3] who used only one valve—a tetrode, in which the anode and screen currents were balanced against each other. In this case, only changes of emission which alter the ratio of the anode and screen currents are detected, and it was found possible to operate in such a way that small variations in emission or in supply voltages did not affect this ratio. This arrangement, while giving very good stability, has one or two disadvantages, in that the operation was limited to a particular point on the valve characteristic and the asymmetry of the circuit made it difficult to compensate for the effects of interference from stray electric fields.

In 1939, Brentano and Ingleby[4] pointed out that the symmetrical nature of the two-valve circuit, together with the improved stability of the one-valve circuit could be combined into the one circuit by using a double electrometer valve—a valve with two anodes and two control grids but only one filament. Such valves have been described by Darbyshire[5] of this laboratory and, in America, by Lafferty and Kingdon[6].

The performance of these valves obviously depends on the extent to which perfect symmetry between the two halves of the double valve has been achieved. The use of a V-shaped filament (as in the split version of the FP.54) makes the attainment of this



The Ferranti Indirectly heated Electrometer Tetrode.

difficult, for a displacement of any one of the three supporting points will mean a lack of symmetry between the two halves of the valve. This difficulty may be partly overcome by the use of a straight filament (as in the Ferranti DBM2).

Another solution, however, is to use an indirectly heated cathode. This has the following advantages:

(a) The cathode is more easily located symmetrically than a filament.

(b) In all electrometer valves the applied electrode potentials must be low in order to avoid producing ionisation in the residual gas. The indirectly heated equipotential cathode is more efficient when used in conjunction with low electrode voltages.

(c) The valve is less susceptible to microphonic disturbances since the cathode may be fixed firmly, whereas a filament has to be supported at one end by a tensioning spring.

(d) The cathode is of necessity larger than the small filament normally used in electrometer valves and has therefore a larger space charge associated with it. This, as shown by Brentano, gives improved stability with respect to changes in battery potentials. (The larger cathode is in one respect a disadvantage, for the grid current is likely to be increased due to increased photo-electric or thermal emission. These effects, however, have not been found to be serious).

An indirectly heated double electrometer tetrode has now been developed by Ferranti Ltd. The tentative rating is as follows:

Type DBM6A
Heater, 4 volts .24 amps.
Screen voltage, 6. Anode voltage, 8.
Anode currents at zero grid bias, 300 μA per anode.
Cut-off voltage, 8 volts (approx.).
Mutual conductance (at $V_g = -3$) = 40 μA per volt (each side).
Amplification factor, 2.5 (approx.).
Control grid currents (both highly insulated) less than 10^{-12} amperes.

Directly heated double valves have a stability of 10-20 mV per 1 per cent. change in heater current, against 50-100 mV for single valves, while the new indirectly heated valves have a stability of 2-5 mV. When used in a DuBridge-Brown circuit this figure is decreased to 0.1 mV, a high degree of stability being retained over a wide range of input signal. This makes them particularly suitable for input stages in D.C. amplifiers.

A single version of this valve has also been developed and is known as the BM6A. It has a higher mutual conductance and amplification factor than the normal directly heated electrometer valve and, owing to the larger space charge produced by the cathode, an improved stability of about 25 mV input grid signal per 1% change in heater current.

The writer wishes to express his sincere thanks to Dr. Darbyshire, Chief Physicist, Ferranti Ltd., for his guidance and encouragement during the development of these valves, and to Ferranti Ltd. for permission to publish this article.

References

[1] Brentano, J. C. M.: *Nature*, 108 (1921), 532.
[2] Wynn-Williams, C. E.: *Trans. Camb. Phil. Soc.*, 23 (1927), 811.
[3] DuBridge, L. A., and Brown, H.: *Rev. Sci. Inst.*, 4 (1933), 532.
[4] Brentano, J. C. M., and Ingleby, P.: *J. Sci. Inst.*, 16 (1939), 81.
[5] Darbyshire, J. A.: *Electronic Engineering* (1946), 277.
[6] Lafferty, J. M., and Kingdon, K. H.: *J. Applied Phys.*, 17 (1946), 894.

* Ferranti Ltd.

The Synchrodyne

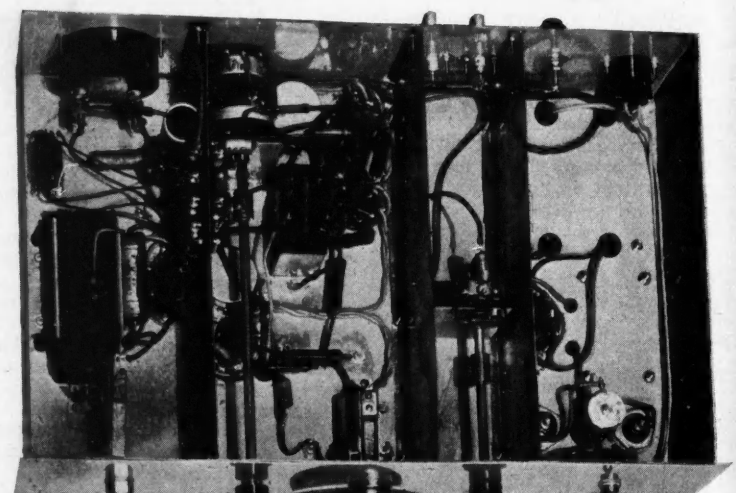
Further Notes on the receiver shown at Radiolympia

by D. G. TUCKER, Ph.D.*

THE photographs on this page show the Synchrodyne receiver made for the G.P.O. stand at Radiolympia. For exhibition purposes it is physically larger than necessary, but it is basically the receiver shown in Fig. 5 of the article in the September issue of ELECTRONIC ENGINEERING. Several refinements have been added, however, notably a device for providing a very considerable suppression of the tuning whistle, a tuning indicator, and a cathode-follower valve in the synchronising path to make the oscillator frequency (*i.e.*, its natural frequency) independent of the setting of the synchronising control potentiometer. In a further article on refinements and extensions to the synchrodyne circuit, these points will be included, together with a full circuit diagram of this exhibition model to illustrate them.

In the top photograph, the right-hand portion of the chassis is occupied by the mains unit, which is perfectly conventional in design. The centre portion comprises the high-frequency section of the receiver. The half of the tuning condenser at the rear of the photograph is the oscillator-tuning condenser, and the pot on its left contains the associated tuning transformer, with the oscillator valve in front. The other part of the tuning condenser and the coil in front of it comprise the aerial tuned circuit, which is highly damped to avoid any restriction in the response of the received signal. This tuned circuit and the first R.F. amplifier valve in front of it are carefully screened by a cover (removed in the photograph) which completely encloses them. The other two valves in this portion of the chassis are the second R.F. stage and the cathode-follower in the synchronising path. The preset control between them is the synchronising control potentiometer. The transformer and rectifiers (crystal type) of the ring demodulator are mounted under the chassis. The two control knobs fitted in this portion of the receiver are the R.F. gain controls; that in the com-

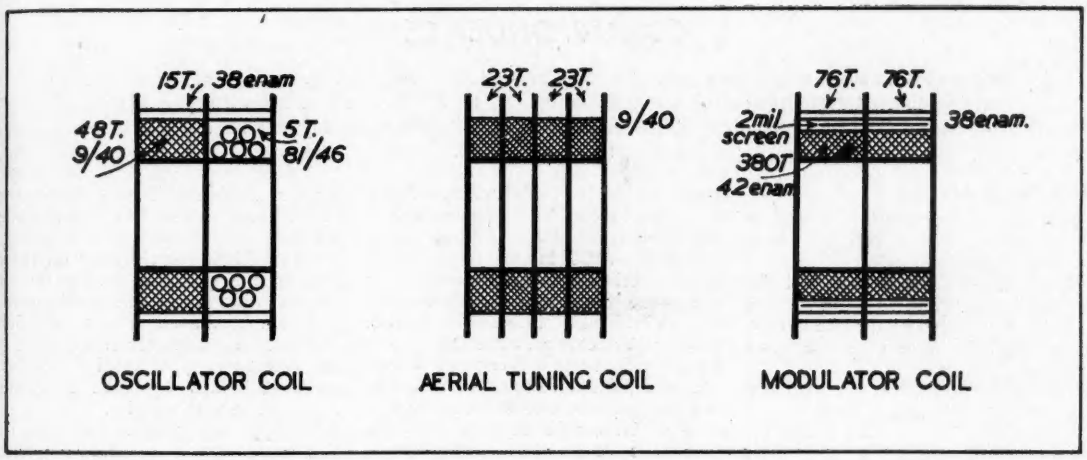
Looking down on the exhibition receiver from the back.



View of underside of chassis, showing also the front plate with slow-motion tuning control.

* Post Office Research Dept.

The Synchrodyne Receiver — Coil Design Data



The following table gives the specification for the coils used in the designs of the Synchrodyne Receiver described in the September issue of "Electronic Engineering." It has not been found convenient to use air-cored coils, and the following iron dust-cores will be required :

For Coils 1 and 3 (Oscillator and transformer) Neosid T.10B.
For Coil 2 (Aerial Tuning) Neosid T.6.

1. Oscillator Coil	2. Aerial Tuning Coil	3. Transformer (T_3)
This is required for all types of circuit (see Figs. 1, 5, and 6 in the Sept. issue).	See Fig. 5 of the Sept. issue.	See Fig. 5 of the Sept. issue.
Tuned Winding : 48 turns of 9/40 Litz. wire 100 μH. Inductance.	23+23 turns, centre-tapped of 9/40 Litz wire 100 μH. Inductance.	Anode Winding : 380 turns of No. 42 enamelled wire 7 mH. Inductance.
Grid Winding : 15 turns of No. 38 enamelled copper 10 μH. Inductance.	The 100 μH. winding of the oscillator coil (No. 1) may be used as the aerial coil of Fig. 5 in place of the special coil if tapped as required.	Rectifier Winding : 76+76 turns centre-tapped of No. 38 enamelled wire. 1 mH. Inductance.
Modulator Winding : 5 turns of 81/46 Litz wire. 1 μH. Inductance.	Alternatively, the 10 μH. winding of the oscillator coil may be used as an aerial coupling coil in place of the tapping arrangement, retaining the 100 μH. coil for tuning.	A copper screen 2 mils. thick is interposed between the windings, the ends of the screen being insulated and any one point connected to earth.
The last winding is not required for the circuit of Fig.6.		

Correction : In Fig. 5 of the design article, the negative feedback arrangement was shown incorrectly. The correct arrangement is R_8 (=25,000 ohms fixed) feeding back to the variable point of the 250 ohm potentiometer replacing R_4. R_9 should be omitted. A 0.01μF. capacitor should be connected from the cathode of V_1 to the variable point.

partment to itself is a potentiometer across the aerial tuned circuit; the other is the negative-feedback control.

The portion of the chassis at the left of the top photograph contains the audio stages. Actually only one valve was fitted, as earphone strength was the requirement (the loudspeaker used for demonstration normally has its own power amplifier); but space was left for a power stage to be fitted when required. The meter seen in this portion was originally intended for monitoring the adjustment of the tuning-whistle suppressor, which involves a negative bias to a rectifier network normally blocking the audio path; this bias is overcome by the D.C. output from the demodulator when synchronism is obtained. The meter reads the D.C. voltage across the rectifier network, and was found to be very useful as a tuning indicator. It is recommended that in any other models of the receiver it should be fitted on the front plate and not at the back. The dry battery, which can be seen at the right of the lower photograph, provides the negative bias to the rectifier network.

One advantage of the generous layout of this receiver is that there is space for the addition of other refinements which may appeal to the user, such as a special oscillator-stabilising and phase-control circuit to be described in the next article. It would then become a receiver of real precision and perfect quality.

Some readers will have seen the small synchrodyne receiver shown on the ELECTRONIC ENGINEERING stand at Radiolympia, and will be interested to know that the circuit was exactly that of Fig. 6 of the September article (one R.F. amplifier valve followed by a triode-hexode demodulator) with the addition of an H.F. pentode (SP41) as a medium-power output stage. One watt output was obtainable from a 10-mV input signal, and under these conditions there was negligible detected interference from an adjacent station only 9 kc/s. away at equal level.

Both these receivers were constructed by Messrs. E. H. E. Barron and J. F. Ridgway, who were also largely responsible for their mechanical design.

The Synchrodyne

CORRESPONDENCE

We publish below a selection (based on the more interesting technical points raised) of the considerable correspondence received following Dr. D. G. Tucker's articles in the March, August and September issues of *Electronic Engineering*. Previous correspondence was published in the July issue.

Mr. B. Starnecki: *

It would be perhaps of interest to you to know that a receiver based on the same principles as the "Synchrodyne" was designed by me in 1934, and patents† were granted to myself and the State Telecommunication Works in Warsaw in 1939.

The only difference between Dr. Tucker's design and mine is that I have combined the oscillator and the modulator in one valve (the early Phillips Hexode E.H.1). In this particular valve a very strong synchronising effect occurred, caused by the internal coupling between the incoming signal and the oscillating part of the valve—as a matter of fact, the valve disappeared from the market as a frequency changer because of this effect.

All the characteristic points of the Synchrodyne are mentioned in the patent specification (*i.e.*, the possibility of obtaining a good selectivity by means of a low-frequency filter only, the necessity of synchronising the local oscillator with the incoming signal, working on the linear part of the characteristic of the modulating valve, etc.). The claims, however, deal only with a receiver in which all the necessary functions (local oscillator, synchronising, modulation) are performed in one single valve of a proper design. It was mentioned in the description that this method is much simpler than any other method necessitating additional devices for modulation and synchronisation.

It might also be worth mentioning that in 1939, the Russians, probably not knowing about the existing patent, published a paper on the same subject in the Russian journal *Elektroswiaz* (No. 6, 1939).

Mr. P. K. Chatterjea:

It seems to me that the process of Homodyne reception is not so very different from that suggested in these articles by Dr. Tucker. While on the staff of the Advance Development Dept. of Messrs. Kolster-Brandes I investigated the field of possibilities of Homodyne reception and found extremely little information thereon or enthusiasm in connexion with them—the only literature providing any worthwhile information being patent specifications. All this had to be shelved due to the urgency of war contracts and developments. But in the meantime it would be of interest if Dr. Tucker could give us some comments on the differences between his method and that of homodyne reception.

The subject is of great interest, if from no other point of view than the attainment of some semblance of an intelligent compromise between the requirements of selectivity and quality.

Mr. D. M. Mackay: ¶

I was rather surprised to read in Dr. Tucker's interesting article the other month,[1] that a distinguishing feature of the Synchrodyne is "the separation of the requirements regarding selectivity and quality, so that each can be adjusted independently of the other."

At first sight this seems to claim an impossible virtue, and indeed one of the more elegant theoretical features of the system is the clear way in which it brings out the well known *interdependence* of adjacent-channel selectivity and audio-frequency response, since both, in the absence of R.F. preselection, depend on precisely the same parameter—the upper cut-off frequency of the audio stage. (Requirements regarding synchronisation are admittedly independent of quality, but are of course additional to the normal "selectivity v. quality" considerations).

This seems to require emphasis, since several readers have, to my knowledge, interpreted the author as claiming to have thrown off the shackles binding the quality enthusiast to an audio bandwidth not greater than the adjacent-channel separation. By no artifice of circuitry (as Dr. Tucker will no doubt agree) can we make the two limits independent.

It is evident (particularly on referring to the previous article on the subject[2]) that a very restricted interpretation of the claim was intended, and there are certainly two aspects of the selectivity problem in the Synchrodyne which ease the inevitable compromise with quality.

Firstly, as pointed out by the author, rejection of the adjacent-channel can be carried out by means of an A.F. filter—an easier design problem than an R.F. filter of comparable bandwidth. Secondly, even an unfiltered synchrodyne's response is *zero* (*i.e.*, entirely inaudible), outside a maximum effective R.F. bandwidth of just twice the frequency-limit of hearing.

In the case of adjacent-channel interference, then, the system does help us to approach more closely the theoretical limit of audio response set by selectivity requirements, though it in no way enables us to exceed it. Moreover, from a practical point of view it does so with great simplification in circuit technique, so that in some marginal cases it is true to say that it would make practicable the high-quality reception of a station which would normally require undesirably complex R.F. filters to separate it from a near neighbour.

This perhaps scarcely justifies the claim that selectivity and quality can be adjusted independently; at the same time, it is hoped that readers will not be deterred from sampling such an excellent "cake" by this warning that they will not be able to "have it" as well!

Points from other Letters

Dr. T. H. Turney comments on the howl produced when tuning in, and considers it would be better to extract the carrier by means of a filter instead of a synchronised oscillator. He had tried out such a system before the present articles were published, using a valve as the modulator, and he emphasises the need to use a non-

* Signals Research and Development Establishment (Ministry of Supply).
† B. Starnecki, Polish Patent No. 28655, June 1939.

¶ University of London, King's College.
[1] August issue, p. 241.

[2] March issue, p. 75.

variable-mu valve, having found the ordinary mixer valve unsatisfactory.

Dr. F. Aughtie (National Physical Laboratory) questions the statement that there is no distortion when the oscillator is working slightly detuned, *i.e.*, still synchronised, but not in the middle of the synchronising range. He points out that in some systems in which a reinforced carrier is supplied via a local circuit, any phase error in the carrier results in harmonic distortion of the audio signal; and he asks whether this applies to the Synchrodyne.

Dr. D. G. Tucker (in reply)

As regards Mr. Starnecki's patent, I have inspected the specification he sent to the Editor. I have not yet been able to obtain a translation, but from the mathematised expressions and from the diagram I can see that he has certainly anticipated me in stating some of the requirements of the Synchrodyne system; but I should think his circuit is rather an improved homodyne than what I intend by the term "synchrodyne." The separation and individual adjustment of the various functions of amplifying, modulating, oscillating, synchronising, etc., as used in my circuits is, I feel, an essential feature if really good and reliable operation over a range of input levels and frequencies is to be obtained. Mr. Starnecki's circuit, in which all these functions are combined, seems unlikely to give as good results in practice.

I have followed up Mr. Starnecki's reference to the Russian journal, copies of which seem extremely rare in this country. I imagine the article he means is the very long one, "Selective Demodulation," by E. G. Momot, on p. 3 of the journal. This discusses at great length the method of demodulation by a tone of the carrier frequency obtained (I surmise) from some sort of synchronised oscillator, and certainly does appear to be related to the method under discussion now. I am having difficulty in obtaining a translation, and so cannot go any further into the matter at present.

As for Mr. Chatterjea's comments regarding literature of the subject, I agree there seems very little, but in previous correspondence[1] I have referred to Colebrook's early article, and Mr. Starnecki (see above) has given two important references. Some British patents which have some bearing on the matter are Nos. 396772, 460179 and 549465. I have already given some comments on the differences between the synchrodyne and the homodyne in previous correspondence, and in my reply to Mr. Starnecki (above).

Mr. MacKay has called me to order on my statement regarding the independence of selectivity and quality. Taken out of its context, the statement is admittedly a little too sweeping, but I hardly think that anyone reading my first article as well as the later ones could misunderstand my claims for the circuit. Mr. MacKay's criticism is, I feel, rather more sweeping, because he does not point out that the inter-channel interference in a conventional receiver comprises not only his relatively inoffensive and almost supersonic "splash" which can be eliminated by a low-pass filter in the A.F. stages, but also the modulation-frequency output (intelligible and covering the whole A.F. range) produced by the *detection* of unwanted signals which get past the R.F. or I.F. filters. I believe this latter type of interference is actually by far the more serious in practice, and my statement is made on this assumption. Consider, for instance, a "quality" receiver which has a R.F. or I.F. bandwidth of 18 Kc/s., in order to allow a 9 Kc/s. audio bandwidth. A station 9 Kc/s. away from the wanted station, at equal strength, receives no filter discrimination against its carrier and one sideband. There is, therefore, no appreciable detector discrimination and an intelligible A.F. signal is produced at a level nearly equal to that of the wanted signal. In a Synchrodyne receiver, there would in such a case be practically no intelligible A.F. signal from the unwanted station, but merely the unintelligible sideband splash (which occurs also in the conventional circuit) mainly at frequencies above 5 Kc/s., where the ear can almost certainly tolerate a much worse signal/noise ratio than at frequencies around 1 Kc/s. For the conventional receiver to be usable in the circumstances, the I.F. bandwidth would have to be reduced to about 10 Kc/s., equivalent to a 5 Kc/s. audio band. Thus the Synchrodyne gives a much better performance on adjacent-channel interference. For interfering signals more remote in frequency, the interference in the output can be made negligible in conventional circuits as in the Synchrodyne, but not with such simplicity of circuit.

As regards Dr. Turney's points, I believe the carrier is extracted from the incoming signal by a filter in one or two commercially-developed systems, such as the exalted-carrier system, and the method is no doubt quite successful. It is, however, rather complicated as compared with the Synchrodyne, and not really suitable for operation over a continuously-variable range of frequencies. I agree about the use of the ordinary mixer valve, and have given warnings in this respect in Part I of my article on Design.

Dr. Aughtie is right in questioning my statement regarding absence of distortion when the oscillator is working near the pull out point. There is, in fact, a slight distortion (which is only occasionally noticeable to the ear, but which can be detected by careful measurement) due to the fact that near the pull-out point, the actual nearness to pull-out varies from instant to instant according to the instantaneous amplitude of the envelope of the incoming signal, and this causes a modulation of the audio output at the modulation-frequency, *i.e.*, harmonic distortion. Thus it is best to work near the optimum point of the range. The effect is not, however, analogous to that mentioned by Dr. Aughtie.

[1] See *Electronic Engineering*, July 1947, p. 238.

Editorial Note :

Much interest was taken in the Synchrodyne receivers shown at Radiolympia on the Post Office and ELECTRONIC ENGINEERING *stands and readers are thanked for their interest and appreciative remarks.*

In response to requests, particulars of the coils used are given on another page and arrangements are being made to supply these through Messrs. Webbs Radio, of Soho Street, W.1., or Messrs. Tele-Radio, Ltd., of 177 Edgware Road, W.1.

Photographs of the simple form of the receiver (see Fig. 16, September issue) are being reproduced later.

For those who have not been able to obtain copies of ELECTRONIC ENGINEERING *containing the original articles, a limited number of reprints of the complete series can be supplied from this office, price 2s. 2d. post free.*

Orders should be accompanied by a Postal Order for this amount, and the envelope should be marked "Synchrodyne," ELECTRONIC ENGINEERING, *28 Essex Street, Strand, W.C.2.*

We will be pleased to hear of the experiences of readers who have already constructed the receiver.

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BOOK

Radar Engineering

Donald G. Fink, (McGraw-Hill Company, Incorporated, London and New York, 1946. 644 pp.)

This excellent book will be most valuable to all who are concerned with the development of radar and allied equipment. It is a remarkable achievement to have covered the whole field of radar up to the end of the war in such a short space. This is made possible only by a pleasingly terse style which makes the book easy to read although highly technical.

The book begins with a delightful chapter giving a short history of radar, followed by a discussion on the uses of radar and the possible ways in which the requirements can be met. As might be expected, the account deals most fully with American developments, but due acknowledgment is made to the British contribution.

The second chapter deals with the principles of pulse generation and transmission. By the use of the Fourier Integral, Mr. Fink makes the theory of transient phenomena easily understood, and his practical examples are chosen to indicate the limitations that are met in the design of pulse circuits. For the computation of actual performance, however, the operational calculus is, in general, less tedious and it is a pity that no examples of the use of this method are given.

The next chapter on " Radio Frequency Fundamentals," begins with a treatment of transmission line theory which is not easily understood. It is better covered in a number of other books, and has, no doubt, only been included here for the sake of completeness. The circle diagram method of calculating impedances is described in detail and is used with good effect throughout the book. The treatment of the physical principles underlying waveguide propagation is excellent and this leads on naturally to the consideration of special waveguide components and then to oscillating circuits and resonant cavities.

The next chapter on " Radiators, Reflectors and Propagation " is a short and adequate introduction to the theory of antennae used in radar equipments, followed by a discussion of the propagation of radar signals over the earth, since this affects the effective vertical polar diagram of the system.

The section on " Radio-frequency Fundamentals " is adequate, and is completed by a discussion of the effect of the shape and size of the target on the reflected signal and a short and valuable description of the use of the Doppler effect for distinguishing moving targets from a stationary background.

The second half of the book, called " Radar Circuits and Components," deals with the design of the components which make up a radar equipment, and everything is covered from the supply mains terminals to the antenna and back to the display equipment.

Four American equipments which could not have been better chosen from the point of view of covering the whole field of radar are used as examples throughout. The first of these, the S.C.R. 268, is a search-light-control radar operating on 205 megacycles. The second, the AN/TUS-3 on 600 megacycles was used for early warning of aircraft and had P.P.I. display. Centimetre wave equipments are represented by the S.C.R. 584, a most suitable choice since it contains almost all the complications required in a modern fire-control radar, and the AN/MPG-1, a coast artillery fire-control radar operating on three centimetres which incorporates all the latest refinements available at the end of the war.

As in the first part, the chapters dealing with pulses and other transient phenomena are outstanding.

Chapter 7, entitled " Basic Radio-frequency Circuits " suffers from an attempt to make it complete. As a result, it reads like an encyclopaedia, and the accounts of the various components are rather superficial. For a proper understanding of the components described in this chapter, a great deal of additional reading in the original papers would be necessary.

The book finishes with a short chapter on radio-frequency measurements which is useful but could have been amplified to advantage.

To sum up, this book gives a very complete and understandable account of the principles, not only of radar engineering, but of the applied physics from which it has sprung. Mr. Fink keeps the practical requirements of radar in mind throughout, and this greatly enhances the value of the book. The only omission is that little reference is made to the mechanical design of the equipments. This is a pity since the eventual performance of a radar equipment is just as dependent on the mechanical design as on the electrical circuits employed.

It is unfortunate that at the time of publication, none of the detailed British work had been published, and so the references are almost entirely American. This is in no way due to an American bias on the part of the author since those British papers which were published at the time are included in the references. The practical radar engineer who uses this book will, therefore, be well advised to have by him a bibliography of British papers on the subject.

J. F. COALES

REVIEWS

British Time

Donald de Carle, (Crosby, Lockwood & Son Ltd.) 199 pp. 15s. nett.

In his introduction to " British Time " Mr. de Carle writes that the aim of his book is to describe the means of recording time and its distribution in the mass, *i.e.*, the distribution of time to the public. This he does in clear and readable form and although the expert may find little that is not already known to him, the student of engineering and to a lesser extent the ordinary layman, can scarcely fail to be interested in Mr. de Carle's story of the human effort to record the passing of time, and having recorded it, to make it generally known.

His brief description of early methods of telling the time as long ago as 1,000 B.C. leads him to a description of the work of Greenwich Observatory from its foundation under Royal Warrant in 1675. On this date, Mr. John Flamsteed was appointed by Charles II to be " our Astronomical Observator " with the express purpose of finding out " the so much desired longitude of places for the perfecting of the art of navigation "; a purpose to the achievement of which, Philip III of Spain had in 1598 and the States General of Holland soon afterwards, already offered substantial rewards.

The growth of Greenwich Observatory under the care of successive Astronomers Royal continues to the present day the close association with the Royal Navy, which its original charter intended, so that in 1882 a movement developed to institute an organisation for testing watches officially, which would be available to British manufacturers. The Royal Society was accordingly prevailed upon to hold tests at Kew Observatory, and these continued, until in 1912 this work was removed to the National Physical Laboratory at Teddington. Mr. de Carle describes the organisation which has been built up at Teddington to test watches to 100th of a second.

The author then deals briefly with the evolution of the clock and goes on to describe in detail the history and working arrangements of Big Ben, which, as a result of the 1939-1945 war, has won for itself fame stretching far beyond the limits of the British Isles.

The chapter on electric clocks with their potential for almost exact accuracy, is of importance and interest in this electrically minded age, though the author's faith in the supply of electricity from the grid may well have been disturbed by the experience of last winter.

Mr. de Carle then turns to the distribution of time in the mass, from the days in the last century when private enterprise obtained the correct time from Greenwich Observatory and reported it by messenger to the clients of the firm in London, to the present day time signals broadcast by the B.B.C. and the golden voice of " TIM." This latter method is described in detail.

The chapter on British Summer Time although appropriate to the book is perhaps of general rather than technical interest.

Some notes of unusual clocks and watches and a review of the watch and clock industry and two appendices complete a most interesting book.

The book is liberally and excellently illustrated throughout. Mr. de Carle confesses that the compiling of his book has given him much personal pleasure; one feels the infection of his pleasure throughout the book.

The style in which the book is written is, perhaps, a little too confidential, too reminiscent of the guide book, which tries to take the reader along in a jolly party. The serious reader wants to know what goes on inside famous places, which he may never have an opportunity of visiting. He does not want to experience unnecessarily the mundane business of getting there.

Lastly, the author should have more faith in his reader. Having explained a technical term once—nutation, for instance—he should assume that his reader has understood and will remember.

C.A.C.-H.

Guide to Broadcasting Stations

Third edition. Compiled by " Wireless World ". (Iliffe & Sons Ltd.)

The demand for this booklet, first published in January as " Broadcasting Stations of the World," has been such that a third completely revised and enlarged edition has been produced.

The lists, giving details of three hundred European medium- and long-wave stations and one thousand short-wave stations of the world, are arranged in both order of frequency and geographically. All entries have been checked against the frequency measurements made at the B.B.C.'s receiving stations at Tatsfield.

The following additional material is included in this edition: wavelength, frequency conversion table, list of international call signs and world time constants.

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NOVEMBER MEETINGS

Institution of Electrical Engineers

All meetings of the London Section will be held at The Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2.

Radio Section

Date: November 5. Time: 5.30 p.m.
Lecture: "Tests for the Selection of Components for Broadcast Receivers."
By: G. D. Reynolds, Ph.D., M.Sc.

Date: November 11. Time: 5.30 p.m.
Discussion: "What Equipment is necessary for the Servicing and Testing of Electronic Devices."
Opened by: Wing Commander P. Allerston, O.B.E.

Date: November 19. Time: 5.30 p.m.
Lecture: "The Cavity Magnetron."
By: H. A. H. Boot, Ph.D., and Professor J. T. Randall, D.Sc.

Lecture: "The High-Powered Pulsed Magnetron—Development and Design for Radar Applications."
By: W. E. Willshaw, M.B.E., M.Sc. Tech., L. Rushforth, B.Sc., A. G. Stainsby, B.Sc., R. Latham, M.A., A. W. Balls, B.Sc., and A. H. King, M.A.

Lecture: "The High-Powered Pulsed Magnetron: A Review of Early Developments."
By: E. C. S. Megaw, M.B.E., D.Sc.

Measurements Section

Date: November 21. Time: 5.30 p.m.
Lecture: "Iron-Loss Measurement by A.C. Bridge and Calorimeter."
By: Professor J. Greig, M.Sc., Ph.D.

The Secretary: I. E. E., Savoy Place, London, W.C.2.

Cambridge and District Group

Date: November 11. Time: 8.15 p.m.
Held at: The Cavendish Laboratory, Free School Lane, Cambridge.
Lecture: "Pulse Communication."
By: D. Cooke, A. J. Oxford, Z. Jelonek, and E. Fitch.

Secretary: J. E. Curran, M.Eng., University of Engineering, Trumpington Street, Cambridge.

The British Kinematograph Society

Theatre Division

Date: November 23. Time: 11 a.m.
Held at: Gaumont-British Theatre, Film House, Wardour Street, London, W.1.
Lecture: "Fundamentals of Colour."
By: W. D. Wright, D.Sc.

Film Production Division

Date: November 5. Time: 6.45 p.m.
Held at: Gaumont-British Theatre, Film House, Wardour Street, London, W.1.
Lecture: "Television Production in Contrast to Film Production."
By: Philip H. Dorte, O.B.E.

Secretary: R. H. Cricks, Dean House, 2 Dean Street, London, W.1.

The Institute of Physics

London Branch

Date: November 19. Time: 2.30 p.m.
Held at: The Lecture Theatre, The Royal Institution, Albemarle Street, London, W.1.
Symposium: The Design of Physics Laboratories.
By: Sir Clifford Paterson, O.B.E., F.R.S., W. F. Higgins, O.B.E., and Prof. T. C. Keeley, M.A.
Note: Visitors will be welcomed to this meeting.
Hon. Secretary: H. L. Penman, London and Home Counties Branch, Institute of Physics, Rothamsted Experimental Station, Harpenden, Herts.

Electronics Group

Date: November 4. Time: 5.30 p.m.
Held at: The Rooms of The Royal Society, London.
Lecture: "Infra-Red Image Converters."
By: J. H. Pratt.
Secretary: Dr. A. J. Maddock, "Sira," Southill Road, Elmstead Woods, Chislehurst, Kent.

The Television Society

Ordinary Meeting

Date: November 5. Time: 6.45 p.m.
Members are invited to the meeting of the British Kinematograph Society.

Date: November 28 Time: 6 p.m.
Held at: I.E.E., Savoy Place, W.C.2.
Lecture: "Impressions of American Television."
By: T. M. C. Lance (Fellow).
Hon. Lecture Secretary: T. M. C. Lance, 35 Albemarle Road, Beckenham, Kent.

Constructors' Group

All meetings will be held at the E.L.M.A. Lighting Service Bureau, 2 Savoy Hill, London, W.C.2.
Date: November 14. Time 7 p.m.
Lecture: "The Reduction of Interference in Television Sound Reception."
By: H. Fairhurst.
Hon. Secretary: A. E. Sarson, 22 Union Road, Bromley, Kent.

The Institution of Electronics

North-West Section

Date: November 6. Time: 6.30 p.m.
Joint meeting with the Illuminating Engineering Society.
Held at: The Reynolds Hall, College of Technology, Manchester.
Lecture: "The Evolution of an Electric Lamp."
By: J. N. Aldington, B.Sc., Ph.D.
Hon. Secretary: L. F. Berry, 105 Birch Avenue, Chadderton, Lancs.

Radio Society of Great Britain

All meetings are held at the Institution of Electrical Engineers, Savoy Place, London, W.C.2.
Date: November 14. Time: 6.30 p.m.
Lecture: "Quartz Crystals."
By: E. A. Fielding.
General Secretary, New Ruskin House, Little Russell Street, London, W.C.1.

British Sound Recording Association

All meetings will be held at the Royal Society of Arts, John Adam Street, London, W.C.2.

Date: November 21. Time: 7 p.m.
Discussion: "What is High Quality Reproduction?"
Opened by: M. G. Scroggie, B.Sc., M.I.E.E.
Hon. Secretary: R. W. Lowden, Wayford, Napoleon Avenue, Farnborough, Hants.

Society of Instrument Technology

Date: November 5. Time: 7 p.m.
Joint meeting with the Society of Glass Technology.
Held at: The Science Museum, South Kensington, London, S.W.
Discussion: "The Instrumentation of Glass Tank Furnaces."
Opened by: H. L. Crooks and C. H. Stone.

Date: November 25. Time: 7 p.m.
Held at: The Royal Society of Tropical Medicine and Hygiene, Manson House, Portland Place, London, W.1.
Lecture: "Electronic Developments in Instrumentation."
By: D. Edmundson, B.Sc.
Hon. Secretary: L. B. Lambert, 55 Tudor Gardens, London, W.3.

British Interplanetary Society

Date: November 8. Time: 6.30 p.m.
Held at: St. Martin's Technical School, 107 Charing Cross Road, London, W.C.2.
Lecture: "Electronics and Space Flight."
By: Arthur C. Clarke.
Secretarial address: 157 Friary Road, London, S.E.15.

South-East London Technical Institute

Electrical Engineering Department

A course of 10 weekly lectures will commence on Wednesday, November 19, 1947, from 7 to 9 p.m., entitled "An Introduction to X-Rays, X-Ray Crystallograph and Metallography." The lectures will be given by J. W. Jeffery, B.A. Further particulars may be obtained from *The Registrar, L.C.C. South-East London Technical Institute, Lewisham Way, London, S.E.4.*

Thames Valley Amateur Radio Transmitters' Society

The next monthly meeting will be held at the Carnarvon Castle Hotel, Hampton Court, on November 5, the subject being "Aerials." *Details from the Press Secretary, N. C. Rogers, The Beadles, Esher, Surrey.*

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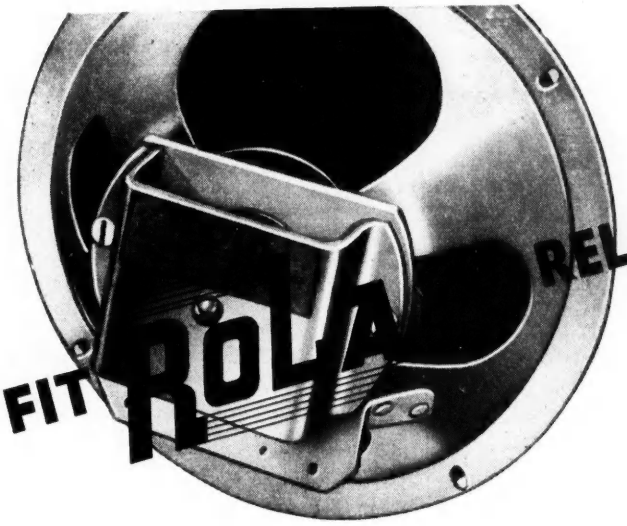

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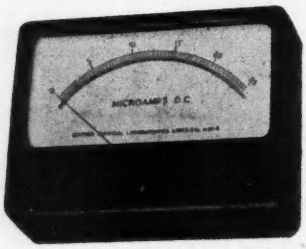

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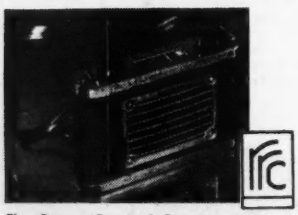

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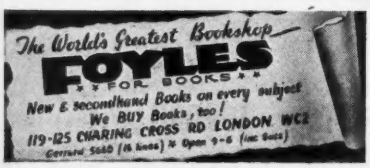
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NOTES FROM THE INDUSTRY

Recent Appointments

The Joint General Managers of the Valve Department of the Mullard Wireless Service Company, Ltd., are Mr. J. E. M. Johns and Mr. D. F. Harrison. Mr. L. A. Sawtell has been appointed Commercial Manager and will be responsible for distribution in the entertainments field.

Dr. W. Summer, the author of the new Monograph on "Photo-cells in Industry," has been appointed Director of Research of Barber Electrical Services, Ltd., and is in charge of development and work on industrial and medico-electronic equipment. The address of this company is Beaumont Road Works, Bournville, Birmingham, 30.

BX Plastics Address

The Birmingham office of Messrs. BX Plastics, Ltd., is now at Empire House, 159 Gt. Charles Street, Birmingham, 3. Telephone: Birmingham Central 2365.

Fluorescent Desk Lamp

The "Fluo" fluorescent desk lamp is being marketed by Truxo, Ltd., 34 South Molton Street, London, W.1. Adjustable, with two 12-in. lighting tubes (each 10 watt), this lamp gives a diffused light of an 80-watt standard bulb, and is priced at £12 plus purchase tax.

Varley Industrial Torch

Oliver Pell Control, Limited, Cambridge Row, Woolwich, London, S.E.18, now have in production a "heavy duty" torch which was primarily designed for use in industry. The torch is robust and so constructed that it will withstand extremely harsh treatment, the case being of hard seamless aluminium alloy.

The torch uses ordinary dry-cell batteries and is priced at 14s. 3d. plus purchase tax.

G.E.C. Radio Compass

In the brief description of the G.E.C. Radio Compass which appeared in the October issue, we omitted to refer to the fact that this instrument was developed by the Salford Electrical Instrument Co., Ltd., a subsidiary of the G.E.C., and that the compass equipment is now in production at the Peel Works, Salford.

Amateur Radio Exhibition

An exhibition of particular interest to amateur radio enthusiasts is being held at the Royal Hotel, Woburn Place, W.C.1, from November 19 to 22 inclusive.

The exhibition is sponsored by the Radio Society of Great Britain and the Exhibition Manager is Mr. H. Freeman, of Parr's Advertising, Ltd. Over 20 stands will be occupied by well-known firms interested in amateur radio. The exhibition will be open from 2—10 p.m. on Wednesday, and thereafter from 11 a.m.; admission by catalogue, price 1s., at the door.

Pye Mobile Television Station

The Pye Mobile Television Station, which was on show at the British Industries Fair, has just completed a successful tour of Belgium, transmitting television pictures for the first time by radio. In all, five towns were visited with a total transmission time of 150 hours.

Nearly 500 miles of Continental roads were covered, and it is interesting to note that the only failures during the entire tour were two miniature type valves and a damaged microphone and headphone cable.

Symbol Standardisation Survey

Co-operating with the service committee of the Radio Manufacturers' Association, John F. Rider, Publisher, Inc., 404 Fourth Avenue, New York, has distributed a "Symbol Standardisation Questionnaire."

The purpose of the questionnaire is to aim at standardising the symbols used in radio receiver and allied equipment manufacturers' service manuals.

The Lowther Manfg. Co.

In the classified list of products at Radiolympia given in the October issue, the name of the Lowther Manufacturing Co. was omitted from the list of Radio Receiver manufacturers.

As the manufacture of radio receivers is this Company's main line of business, the omission is unfortunate, and we have pleasure in making amends by this note.

The words "Lowther-Voigt" are a trade mark, which has been adopted by agreement with Messrs. Voigt Patents, Ltd., but otherwise there is no connexion between the two companies.

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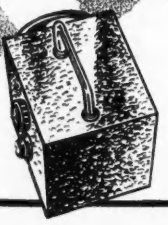

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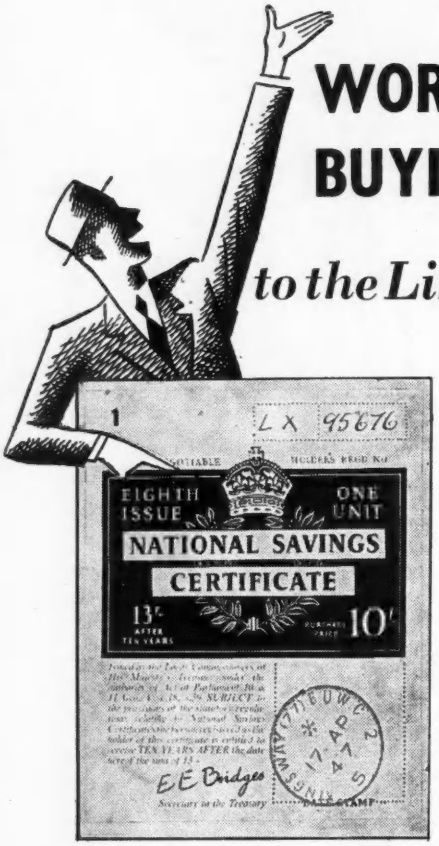

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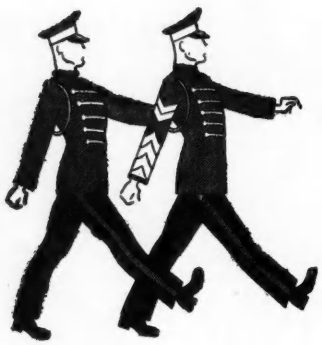

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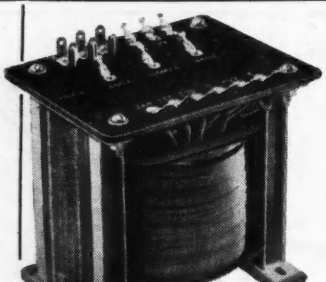

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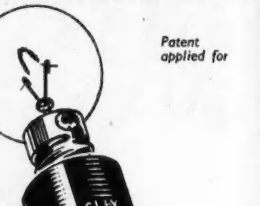

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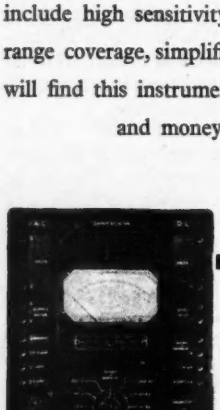

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SANGAMO WESTON LTD., ENFIELD, MIDDX. Telephone : Enfield 3434 & 1242

CLASSIFIED ANNOUNCEMENTS

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FOR SALE

IN STOCK. Rectifiers, Accumulator Chargers, Rotary Converters, P.A. Amplifiers, Mikes, Mains Transformers, Speakers of most types, Test Meters, etc. Special Transformers quoted for.—University Radio, Ltd., 22, Lisle Street, London, W.C.2. GER. 4447.

ENAMELLED COPPER WIRES for sale in substantial quantities, 17, 19, 20, 21,.24, 25 and 33 S.W.G. Box 148, "Elec. Engg."

EX-R.A.F. LORAN Indicators with 5 in. electrostatic c.r.t. with time base. 26 valves, including 6SN7, 6H6, 6SJ7 and calibrated 100 Kc. crystal, suitable for conversion to oscillograph, £10. Box 146, "Elec. Engg."

D.C./A.C. CONVERSION. Special offer of unused single phase marine type motor alternators. Input 220 V D.C., output 230 V A.C., 50 cycles, 3.5 amps., £20 each. 220 V D.C./230 V A.C., 50 cycles, 0.87 amps., £12 10s. each. 110 V D.C./230 V A.C., 50 cycles, 0.87 amps., £9 10s. each. Control gear not available. Carriage extra. Box 144, "Elec Engg."

RELAYS. New boxed Post Office type relays, some fitted with high current contacts, offered at a fraction of cost price. Type K, coil, 1,000 ohms, contacts 1 break, 1s. 9d. each. Type L, 1,000 ohms, 3 make, 1 b., 3s. 6d. each. Type M (miniature), 300 ohms, 1 b., 1s. 3d. each. Type N, 1,000 ohms, 1 m., 2 m., ½ in. dia., 5s. each. Type O, 5,000 ohms, 2 m., 2 b., all 2.5 mm. dia., 7s. 6d. each. Type P, 1,000 ohms, 1 m., 1 b. 1 m., ½ in. dia. 4s. each. Type R, 1,000 ohms., 3 m. 1 b. (all heavy duty twin type), 4s. each. Type S, 765 ohms, 4 m., 1 b., 4s. each. Type U, 1,000 ohms, 3 m., 1 b., 1 m., ½ in. dia., 4s. 6d. each. Type W, 1,000 ohms, 2 high sensitivity change-overs each adjustable by thumb screw, 4s. each. Also Type X, special 75 ohms twin coil high-speed relay, up to 100 c. p.s., 5s. each. Send s.a.e. for leaflet. Minimum order £1. No C.O.D. discount for quantities. Box 145, "Elec. Engg."

BRITISH-AMERICAN Radio, Electronic Components, list 1d. Jack Porter Ltd., College Street, Worcester.

2" MOVING COIL METERS, 0-20, 0-40 volts, 7s. 9d., 0-300 volts, external resistance, 10s. All boxed new, post paid. Jack Porter Ltd., College Street, Worcester. (Quotation for quantities.)

FOR YOUR HOME-BUILT TELEVISOR.—Highest quality EF50 VHF holders, 1s.; 10 for 8s. 6d. Why pay more? Midget 500pf. mica condensers 4s. doz. Watts, 38 Chapel Avenue, Addlestone, Surrey.

AMATEUR RADIO SERVICE G6HP, Canning Street, Burnley, for all amateur equipment. The main amateur service of the North. Amplifiers, modulators, complete transmitters, Franklin V.F.O.'s, oscilloscopes, panels, chassis, racks. Bargains in ex-Service gear. S.A.E. for comprehensive lists.

A.C./D.C. MILLIAMMETERS. 2" dial, thermocouple moving coil, 0-350m/a. New ex-Government. A bargain at 5s. 6d. each, £3 3s. per dozen, post free. S. McMillan, 5 Oakfield Road, Bristol, 8.

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LOUDSPEAKERS—We carry on. Sinclair Speakers, 12, Pembroke Street, N.1.

LOUDSPEAKER repairs, British, American, any make, moderate prices.—Sinclair Speakers, 12, Pembroke Street, N.1.

MISCELLANEOUS

WE WILL BUY at your price used radios, amplifiers, converters, test meters, motors, pick-ups, speakers, etc., radio and electrical accessories. Write, phone or call, University Radio Ltd., 22, Lisle Street, London, W.C.2. GER. 4447.

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MORSE Practice Equipment for Class-room or Individual Tuition. Keys Audio Oscillators for both battery or main operation. Webb's Radio, 14, Soho Street, London, W.1. 'Phone: GERrard 2089.

COPPER WIRE. Enamelled, tinned, cotton, silk-covered, 16-46 S.W.G.; screws, nuts, washers, soldering tags, eyelets, rivets, ebonite and laminated bakelite panels, coil formers, covered wires, flexes, crystals, permanent detectors, earphones, etc. List available. Trade supplied. Post Radio Supplies, 33, Bourne Gardens, London, E.4.

AID YOUR EXPORT DRIVE. Exceptional photography will make your products sell. Consult P and C (Photos), 35 Sandringham Road, Dalston, E.8.

DETAILED DRAWING for precision production engineering to your specification, circuit diagrams, etc. Drawing office facilities available for mechanical, radio and electronic apparatus. Wordsworth 4476.

BRAND NEW ELECTRIC CABLE. Flat low twin 3/.029. 250 volts. V.I.R. T.B. & C. £17 15s. 1,000 yards. Sample 100 yards £2. Discounts quantities. Also auto, ignition, flexes, radio and starter cables at big savings. Ref. 5002. M.W. and C. Co. Ltd., 82/94 Seymour Place, London, W.1.

ACCUMMULATOR or Battery Boxes, 34,000 available. Size 4½" L × 3½" W × 8½" H. With or without lids. Made of 6 mm. Bitumen compo, which can easily be cut to smaller size. Low price for quantities. Box 2200, G.T.C. Ltd., 82/94 Seymour Place, London, W.1.

BRITAIN'S BEST BARGAINS in electric cable, 8½ mill. yards available at big reductions covering Auto, Ignition, Flexes, Radio and Starter Cable. List, free on application to Box 5004, Magna Ltd., 82/94 Seymour Place, London, W.1.

OFFICIAL APPOINTMENTS

BRITISH BROADCASTING CORPORATION invites applications from men or women (British) for the post of engineer in the Ionosphere section of the Overseas and Engineering Information Department, based in London. Applicants must have a knowledge of radio engineering with a highly specialised knowledge of short-wave transmission and reception, and the propagation of radio waves and the effects of the Ionosphere upon them. They must also be able to calculate and prepare maximum usable frequency curves for any path required and be able to forecast ionospheric conditions when given the necessary data. Salary on appointment will be dependent on qualifications and experience and subject to favourable reports will rise thereafter by annual increments of £25 to a maximum of £580. Applications stating age, qualifications and experience should reach the Engineering Establishment Officer, Broadcasting House, London, W.1 within 14 days of the appearance of this advertisement.

SITUATIONS VACANT

Vacancies advertised are restricted to persons or employments excepted from the provisions of the Control of Engagement Order, 1947.

FERRANTI LIMITED require for Vacuum Physics Laboratory Physicists or Engineers, graduates or with equivalent qualifications, preferably with experience of electronic vacuum work or U.H.F. valves. Application forms from Personnel Manager, Ferranti Limited, Ferry Road, Edinburgh, 5.

MURPHY RADIO, LTD., have a vacancy for a senior engineer having considerable experience in the development and design of communication receivers and allied equipment. Apply in the first place in writing, giving full particulars and stating salary required, to Personnel Department, Murphy Radio, Ltd., Welwyn Garden City, Herts.

SENIOR DEVELOPMENT ENGINEER required in television design laboratory. Good honours degree in physics or engineering and at least four years' industrial experience of television receiver development essential. Applications, giving full particulars of training and experience to Personnel Manager (Laboratory), Murphy Radio Ltd., Welwyn Garden City, Herts.

RADIO SERVICE ENGINEERS for employment in works and in field. Vacancies exist in a well-known company with excellent prospects, primarily in the London area. Applicants should have a comprehensive knowledge of radio servicing and a minimum of two to three years' retail or industrial experience in repair work. 5-day, 44-hour week. Wages according to experience and at prevailing levels. Apply, stating age, giving full details of experience and wages required to Box 113, "Elec. Engg."

RADIO AND ELECTRONIC Draughtsman for layout work, etc., used to mechanical design of electronic equipment required for research section. West London district. 38-hour 5-day week. In applying, give full details of experience, qualifications, age and salary required, to Box 117, "Elec. Engg."

PHYSICISTS AND ENGINEERS are required by Imperial Chemical Industries Ltd., for work in connection with the instrumentation and automatic control of chemical plants. Vacancies exist for staff for research and development work, as well as for installation and maintenance of instruments on site.
Candidates aged 21/35, must have first or second class Honours degree in Physics or Engineering. Experience either in the Forces on radar or servo mechanisms, in the aircraft industry or instrumentation and automatic controls, or in industry on plant control, would be an advantage. Suitable applicants not possessing the necessary amount of practical experience will be given additional training before being posted.
Good prospects of advancement. Starting salary according to age and qualifications.
Apply in writing and quoting E/5, to Staff Manager, Imperial Chemical Industries Limited, General Chemical Division, Cunard Building, Liverpool 3.

ELECTRONIC ENGINEERING. An important position in this industry is available to a man of outstanding qualifications, experience and administrative ability, with leading manufacturer of radio transmitting and receiving and electronic equipments, as Manager of large self-contained production unit employing over 1,000 persons. with fully equipped laboratory and development section. Salary £1,200 or over according to qualifications. Write quoting D.326/47—A to Ministry of Labour and National Service, Technical and Scientific Register, Room 669, York House, Kingsway, London, W.C.2, for application form which must be returned completed by 30 November, 1947.

LECTURER in Radio Communications required with Science Degree or equivalent, and a good practical outlook. Age preferably not over 30. Apply by letter giving fullest details of age, education, experience and salary required to The Principal, E.M.I. Institutes Ltd. (Associated Company with H.M.V., Columbia and Marconiphone, etc.); Grove Park Road, Chiswick, W.4.

JUNIOR ENGINEER required for development of radio components by progressive company in London area. Degree or equivalent in electrical engineering essential. Box 127, "Elec. Engg."

DESIGNER DRAUGHTSMAN with experience of instrument or light electrical engineering work required by large company in East London area. Suitable applicants should be capable of working on own initiative. Apply stating age, experience and salary required to Box 128, "Elec. Engg."

VALVE ENGINEER. A vacancy occurs with a well-known firm for an engineer to act in the capacity of technical assistant to the Works Manager. Must be capable of handling problems arising in connection with the design and manufacture of radio transmitting valves. Write stating technical qualifications, experience and salary required to Box 132, "Elec. Engg."

RADIO ENGINEER required for research work by large manufacturer in the Essex area. Suitable applicants must have technical qualifications to degree standard and have previous experience of research work. Experience of direction finding equipment would be an advantage. Apply stating age, experience and salary to Box 137, "Elec. Engg."

PLANNING ENGINEER with experience on mass production assembly work required by a large light engineering company in the East London area. Replies should state age, experience and salary required to Box 131, "Elec. Engg."

CLASSIFIED ANNOUNCEMENTS (Contd.)

ELECTRONIC ENGINEER preferably with industrial experience in application of electronic devices in design and development vibration engineering. Please write stating age, qualifications and salary required to Box 129, "Elec. Engg."

MOUNT VERNON HOSPITAL and the Radium Institute, Northwood, Middlesex. Laboratory steward required for the physics department. Duties include custody of radium (no previous experience necessary), storekeeping, issue, assembly and repair of apparatus, dismantling of used apparatus, record keeping, and preferably glassblowing. Possession of Certificate of Laboratory Arts would be an advantage. Salary scale £275–15–£350, commencing point in accordance with qualifications and experience. Appointment subject to approval of the Ministry of Labour. Applications, with copies of testimonials or names for reference, should be sent to the Secretary (from whom further particulars may be obtained) not later than November 10, 1947.

DESIGN ENGINEER required by firm specialising in communication and amateur equipment. Must be capable of electrical and mechanical design of receivers, low power transmitters, etc. Degree standard preferred but not essential. Unusual opportunity for engineer able to put new ideas in production from start to finish. Sound knowledge of amateur equipment essential. Please state fully experience and salary required to Box 134, "Elec. Engg."

LEADING LONDON amateur dealers have vacancies for counter staff. Seniors (must be HAMS) and juniors. Vacancy also for shorthand-typist. Full details and salary required to Box 135, "Elec. Engg."

JIG AND TOOL designer with experience on light electrical engineering required by large manufacturing concern in East London area. Suitable applicant must be able to work on own initiative. Apply stating age, experience and salary required to Box 133, "Elec. Engg."

EXPERIMENTAL ENGINEER capable of assisting in development of electro-acoustical apparatus and sound recording systems. B.Sc., or equivalent qualication preferred. West Middlesex district. Apply stating age, details of education and experience to Box 136, "Elec. Engg."

SENIOR DESIGN ENGINEERS required for electronic and electrical test equipment used for production testing. London area. Applicants write stating age and experience to Box 138, "Elec. Engg."

REQUIRED IMMEDIATELY by large firm in E. London area, engineers for development work on H.F. and V.H.F. transmitting and receiving equipment. Applicants should have a degree in either physics or engineering, and experience in some aspect of the above mentioned work, or should have very extensive experience of responsible work on projects in this field. Only first-class engineers can be considered for these posts. Apply stating age, experience and salary required to Box 139, "Elec. Engg."

LONDON APPOINTMENT offered to Assistant Physicist with a leaning to radio and electrical circuits. Applicants should have appropriate electrical qualifications and not less than two years experience, and will be required to develop the electrical aspects of plastics evaluation in a large chemical manufacturing company. The work offers prospects for promotion. Commencing salary range £375–£500. Box 140, "Elec. Engg."

MEDICAL RESEARCH COUNCIL. Pneumokoniosis Research Unit (South Wales) have a vacancy for a graduate in Physics or electronic engineering for designing and assembly of electrical recording devices for physiological and dust measurements. Experience in capacity-resistance and photoelectric measurements would be an advantage. Workshop experience essential. Initial salary £415–£540 per annum. Applications, with full details of qualifications and experience should be sent to the Director, Pneumokoniosis Research Unit (South Wales), Llandough Hospital, nr. Cardiff, and should give names of two referees—one professional and one personal.

RADIO TEST GEAR Maintenance Engineer for maintenance and development of production and laboratory test equipment. Five-day week. Salary according to age and experience. Write Personnel Officer, Ferguson Radio Corporation Limited, Gt. Cambridge Road, Enfield.

APPLICATIONS INVITED from men of 25-30 years of age with suitable qualifications and/or experience in the use and application of industrial high frequency equipment, to fill progressive positions as sales engineers at home and abroad. Write stating age, experience and salary expected to Box 143, "Elec. Engg."

GRADUATE DEVELOPMENT ENGINEER, with laboratory experience in electronic development, preferably of amplifiers for very low frequencies, biological amplifiers and electronic instruments. Eastern outskirts of London. Write full details and salary required to Box 150, "Elec. Engg."

SITUATIONS WANTED

HONOURS GRADUATE, 22, works laboratory and research experience, seeks position as research or development engineer. Box 142, "Elec. Engg."

GLASSBLOWER, 18 years experience hard and soft glass. Vacuum and electronic apparatus. Wide range technical data. Desires sound lab. or supervisory position. Box 130, "Elec. Engg."

ASSISTANT WORKS MANAGER or similar post wanted by chief engineer of development company. Box 141, "Elec. Engg."

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A.M.I.E.E. Examinations. Electrical engineer-lecturer (B.Sc. (Eng.) Hons. A.M.I.E.E.) specialises in private individual tuition. Vacancies for April 1948 exam. Personal or correspondence. Box 147, "Elec. Engg."

SPEECH DISABILITY: Mr. H. V. Hemery consults at Wigmore Hall Studios, Wigmore Street, W.1.

PRIVATE COACHING in electrical and radio engineering for A.M.I.E.E. and B.Sc. examinations, by experienced lecturer and engineer. Box 119, "Elec. Engg."

THE UNIVERSITY OF MANCHESTER. Post-graduate course in high-vacuum technique and advanced electronic tubes. The next session of the course which is of six months' duration will commence in January 1948. The desired qualification for entry is an Honours degree in electrical engineering or physics. The fee for the course is £25. Particulars of the lecture and laboratory work will be supplied on application to the Professor of Electrotechnics, The University, Manchester 13.

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ENAMELLED COPPER WIRES on reels urgently required between gauges 22 to 46 S.W.G. Detailed offers to Box 149, "Elec. Engg."

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Se/Te on gold-alloy, super-sensitive to light, gas-filled, permanent, operate a relay by light, either direct or through one-valve amplifier, also reproduce speech and music, etc., perfectly from sound track of films; large tube 3½ in. from glass top to valve pin base, 1 in. dia., 35/-; same type, 2½ in. long, 30/-; small tube, 2 in. from top to terminal base, ¾ in. dia., 28/-; miniature cell, glass top to cap base, 1 in. overall, ½ in. dia., thin flex leads, 25/-; all cells operate on 40-100 volts. Wiring diagrams for relay and film sound amplifier free.
PRECISION OPTICAL SYSTEM
For sound film, producing very fine line of light from 6 or 12-volt 1 amp. lamp, for scanning film sound track direct into photo-cell, metal tube 1½ in. long, ⅜ in. dia., ⅜ in. focus, 52/-. Full directions free.
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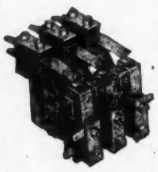
RELAYS
For A.C. and D.C.



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Hermetically Sealed

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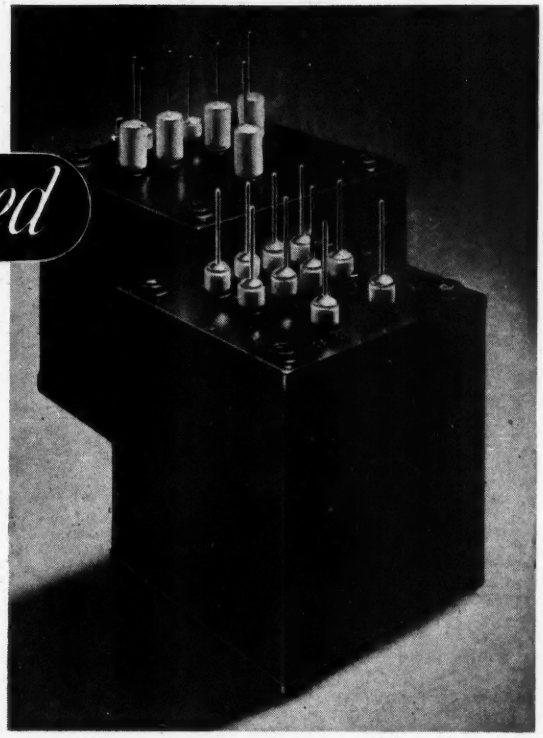

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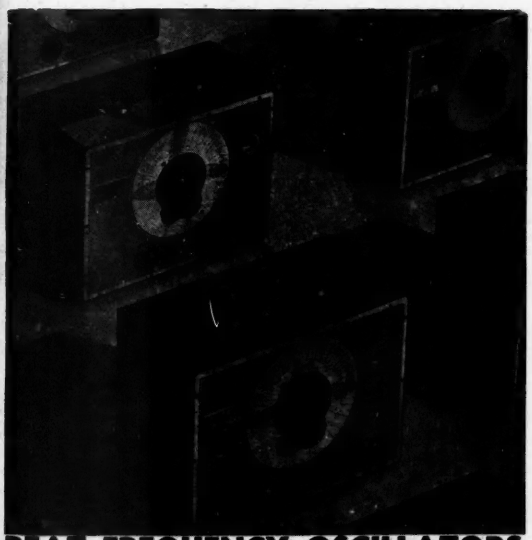

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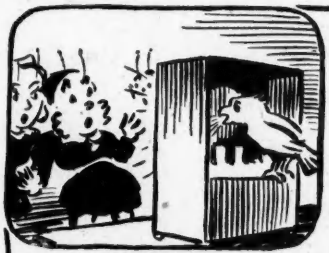

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"I'm sure we fixed it all right
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"Now twerps—go and fetch the FLUXITE".

For all SOLDERING work—you need FLUXITE—the paste flux—with which even dirty metals are soldered and "tinned." For the jointing of lead—without solder; and the "running" of white metal bearings—without "tinning" the bearing.

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Used for over 40 years in Government Works, and by leading Engineers and Manufacturers, OF ALL IRONMONGERS—IN TINS—10d., 1/6 and 3/-.

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FOR DIVERSITY OF STOCK

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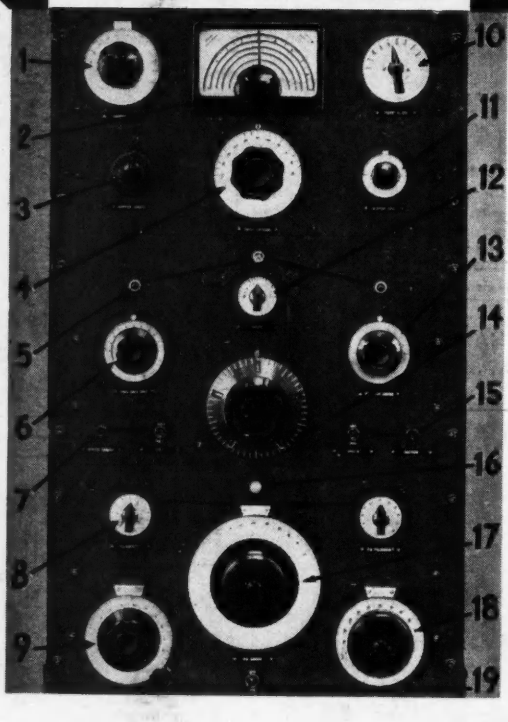
Dials & Panel Fitments



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5 **Bulgin** dial lamp holder, type 19 ... ... **2/3**

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10 **Eddystone No. 62** Pointer Knob and Scale, diameter of scale 3" **2/-**

11 **Eddystone No. 639.** Precision miniature 2" dial. Reduction 10/1. With indicator. Engraved black on silver **15/-**

12 **Eddystone No. 425** Miniature Pointer Knob and Dial, scale diameter 1¾" ... **1/8**

13 **Muirhead D130A.** Direct Drive, scale dia. 2¾". Complete with skirt knob **13/6**

14 **Muirhead "H.R.O."** S.M. Drives, type D115A **£6/14/-** type D206A **£7/2/6**

15 **Webb's** Transmitter labels, 1⅞"×$\frac{11}{32}$" ... ... **4d.**

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Webb's Transmitter Labels. Engraved white on black with 8 B.A. fixing holes. Size 1⅞"×$\frac{11}{32}$". In 30 markings for. Transmitter use. All at **4d.** each.

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